DROUGHT AND DROUGHT MITIGATION IN YOBE STATE, NIGERIA

By

Abdullahi Hassan Gana BSc, MSc

A thesis submitted in partial fulfilment of the requirements of the University of Wolverhampton for the degree of Doctor of Philosophy (PhD)

October 2018

Signature:…….

Date:…….

ABSTRACT

Drought is regarded as a natural phenomenon and its impacts accumulate slowly over a long period. It is considered to be insufficient precipitation that leads to water scarcity, as triggered by meteorological parameters, such as temperature, precipitation and humidity. However, drought mitigation has mostly been reactive, but this has been challenged by extreme events globally. Many countries and regions around the world have made efforts in mitigating drought impacts, including Nigeria.

This research produced frameworks for drought amelioration and management as a planning tool for Yobe State, Nigeria. Mixed methods were employed to investigate the effects of drought; 1,040 questionnaires were administered to farmers in three regions of Yobe State (South, North and East). Some 721 were returned, representing a 69.3% return rate. Drought is pronounced in the State and has been recent over the years; it has also affected many people, with losses of ~70-80% of their harvests and livestock. Drought coping strategies have also caused environmental degradation in Yobe State. Farmers over-harvest their farms, practise deforestation and over-exploit wild animals. Several efforts to mitigate the impacts of drought by the Nigerian Government have failed, thus this research adopts a bottom-top approach to mitigate drought impacts in Yobe State. Focus Group Discussions (FGD) were also conducted at government and community levels to gather farmers' and government officials' opinions on their drought experience and suggestions for mitigation measures. Farmers believed that rainfall is their main problem and officials pointed that there are no proper drought mitigation plans in Yobe State.

Four validated drought mitigation and management frameworks were developed for Yobe State. The frameworks were evaluated pre-use through respondent validation. State officials and farmers believed that these frameworks will reduce the impacts of drought in Yobe State. The frameworks include social, economic, environmental impact mitigation and an Integrated Drought Mitigation and Management Framework. The proposed frameworks were designed and have advocates a paradigm shift, using both proactive and reactive measures. A new drought definition was proposed based on the findings of the study. The definition states that *drought is the shortage of rainfall or water that affects people's livelihood and the environment both directly and indirectly.*

DEDICATION

I have dedicated this work to my family for their support throughout the period of my study.

TABLE OF CONTENTS

DROUGHT AND DROUGHT MITIGATION IN YOBE STATE, NIGERIA.....i
ABSTRACT.....ii
DEDICATION.....iii
TABLE OF CONTENTS.....iv
LIST OF FIGURES.....x
LIST OF PLATES.....xi
LIST OF TABLES.....xii
ACKNOWLEDGEMENTS.....xv
GLOSSARY.....xvi
1. CHAPTER ONE: INTRODUCTION.....1
1.1. Chapter overview.....1
1.2. Definitions of droughts.....1
1.2.1. Drought definition in the context of this research.....2
1.3. Types of drought.....3
1.3.1.1. Meteorological drought.....3
1.3.1.2. Agricultural drought.....4
1.3.1.3. Hydrological drought.....6
1.3.1.4. Socio-economic drought.....7
1.4. Background of the study.....8
1.4.1. Statement of problems.....9
1.4.2. Study area.....11
1.4.3. Rainfall distribution in Nigeria and Yobe State.....12
1.4.4. Research questions.....15
1.5. Research aims.....15
1.5.1. Aim One.....15
Objectives.....16
1.5.2. Aim Two.....16
1.6. Thesis structure.....17
2. **CHAPTER TWO: LITERATURE REVIEW.....19**
2.1. Introduction.....19
2.2. Effects of climate change.....19
2.2.1. Climate change and ecosystem services.....21
2.2.2. Climate change and extreme weather events.....22
2.2.3. Impacts of climate change in Nigeria.....23
2.3. Vulnerability to drought.....24
2.3.1. Adaptive strategies.....25

2.3.2. Impact of drought on income and coping strategies in semi-arid regions 26
2.4. Socio-economic effects of drought 27
2.4.1. Famine and drought 29
2.4.2. Effects of drought on conflict 29
2.5. Effects of drought around the world 30
2.5.1. Effects of drought in Asia and Australia.....30
2.5.2. Effects of drought in the USA and Canada.....32
2.5.3. Effects of drought in Europe.....33
2.5.4. Effects of drought in Africa 35
2.5.5. Environmental problems in Africa.....38
2.5.5.1. Deforestation 39
2.5.5.2. Land degradation and management.....39
2.6. Effects of drought in Nigeria.....40
2.6.1. Impacts of the 2009 drought in Yobe State 42
2.6.2. Hydrogeology of Yobe State and potential for irrigation 43
2.7. Identifying stakeholder's role in adaptation strategies.....44
2.8. Challenges of drought proactive preparedness.....45
2.9. Drought mitigation measures in different countries around the world 47
2.9.1. Central East Europe (CEE) drought mitigation plan 47
2.9.2. Drought management plans in Spain 49
2.9.3. Mexican National Drought Policy (PRONACOSE).....49
2.9.4. Australia's drought policy.....51
2.9.5. Drought management in South Africa 53
2.10. Importance of Early Warning Systems in decision making 53
2.10.1. Factors affecting Early Warning Information 54
2.10.2. Methods of improving Early Warning Systems in decision making 56
2.10.3. Importance of indigenous knowledge in drought mitigation 56
2.11. Improving drought monitoring and management.....56
2.11.1. The drought monitoring system of the USA 57
2.12. Need for national drought policy.....59
2.12.1. General strategies for implementing National Drought Policy.....61
2.12.2. Critical appraisal of policies and efforts made by Nigerian governments to mitigate impacts of drought.....63
2.13. Gaps identified based on literature review and critical appraisal of Nigeria approach70
2.14. Summary.....71
3. **CHAPTER THREE: RESEARCH METHODOLOGY 73**

3.1. Introduction 73
3.2. Research design and approach 73
3.3. Mixed methods 74
3.4. Quantitative methods 75
3.4.1. Sample size determination 76
3.4.2. Pilot study questionnaire testing 78
3.4.3. Main questionnaire survey 79
3.4.4. Descriptive statistics 81
3.5. Qualitative methods 82
3.5.1. Focus Group Discussion 83
3.5.1.1. Procedure for Focus Group Discussion (FGD) 84
3.5.2. Sessions of the FGDs 85
3.6. Research validation 85
3.6.1. External validity 86
3.6.2. Internal validity 87
3.7. Ethical considerations 88
3.8. Summary 88
4. CHAPTER FOUR: DATA ANALYSIS FROM THE QUESTIONNAIRE SURVEY…… 89
4.1. Introduction 89
4.2. Survey data analysis 89
4.2.1. Respondents' employment status and farming time 90
4.2.2. Respondents level of drought knowledge 91
4.2.3. Respondents as drought victims and people they know 91
4.2.4. Respondents harvest loss and impacts of drought on social activities 92
4.2.5. Impact of drought on respondents' income and past droughts 93
4.2.6. Respondents' harvest loss 93
4.2.7. Responses on how drought affects their income 94
4.2.8. Respondents' response to causes of drought and its impacts on livestock 94
4.2.9. Number of dead livestock 95
4.2.10. Conflict due to drought and harvest storage 95
4.2.11. Respondents' drought coping strategies 96
4.2.12. Livestock for drought compensation 97
4.2.13. Respondents' coping strategy for persistent drought and irrigation practise 97
4.2.14. Respondents' dependency on the natural environment 98
4.2.15. Drought and environmental damage 99
4.2.16. Responses on increased desertification 99

4.2.17. Drought social welfare and infrastructure 100
4.2.18. Responses of interventions received and required 101
4.2.19. Cross-tabulation of past drought events and regions 102
4.2.20. Cross-tabulation of harvest loss according to regions 102
4.2.21. Cross-tabulation of desertification within regions 104
4.3. Analysis of average rainfall and crop production in Yobe State 105
4.4. Open ended questions analysis 108
4.5. Summary 109
5. CHAPTER FIVE: ANALYSIS OF FOCUS GROUP DISCUSSIONS 111
5.1. Introduction 111
5.1.1. Responses with farmers at community level 111
5.2. Changes in rainfall patterns in Yobe State 111
5.3. Farmers' contribution to environmental degradation 112
5.4. Farmers responses to drought mitigation 114
5.4.1. Farmers suggestions on drought mitigation 116
5.5. FGD session with the Ministry of Environment Officials 118
5.5.1. Problems of drought in Yobe State 119
5.5.2. How policy can mitigate impacts of drought in Yobe State 120
5.5.3. Challenges of implementing a drought policy in Yobe State 123
5.5.4. Paradigm shift as measure of drought mitigation 123
5.5.5. Environmental threats due to drought 124
5.5.6. Measures for drought mitigation by both sessions 125
5.6. Summary 126
6. CHAPTER SIX DISCUSSION OF FINDINGS 128
6.1. Introduction 128
6.2. Assessment of drought mitigation policies in Nigeria 128
6.2.1. Nigeria Drought Policy (National Drought and Desertification Policy, 2007) 129
6.3. Impacts of drought in Yobe State 130
6.4. Mitigation measures and paradigm shift 132
6.5. Irrigation as a mitigation measure 134
6.6. Environmental problems and management 134
6.7. Answering research questions 136
6.8. Summary 137
7. CHAPTER SEVEN: DROUGHT MITIGATION FRAMEWORK DEVELOPMENT AND EVALUATION 138
7.1. Introduction 138
7.2. Preliminary conceptual framework 138

7.3. Framework development 140
7.4. Drought mitigation frameworks 140
7.4.1. Social Impacts Drought Mitigation Framework 141
7.4.2. Economic Impacts Drought Mitigation Framework 144
7.4.3. Environmental Impacts Drought Mitigation Framework 149
7.4.4. Sector frameworks implementation 152
7.5. Drought management strategies 152
7.5.1. Drought policy as part of the framework 155
7.5.2. The Integrated Framework 155
7.5.3. Importance of implementing the Integrated Framework 156
7.6. Framework evaluation process 159
7.6.1. Framework evaluation responses from farmers 159
7.6.2. Evaluation responses from the Ministry of the Environment officials 160
7.6.3. Farmers' and Ministry of the Environment officials views of the frameworks 160
7.7. Summary 161
8. CHAPTER EIGHT: CONCLUSIONS AND RECOMMENDATIONS 163
8.1. Introduction 163
8.2. Achievements of research Aims and objectives 163
8.2.1. Achievement of aim 1 and objectives 163
8.2.2. Achievement of Aim 2 and objectives 164
8.3. Summary of findings from the study 165
8.4. Contributions to knowledge 167
8.4.1. Contributions to theory 167
8.4.2. Contributions to methodology 167
8.4.3. Contributions to practise 168
8.5. Conclusions from the research 168
8.5.1. Limitations of the study 169
8.5.2. Recommendations from research outcomes 170
8.5.3. Recommendations for further research 170
References…. 172
APPENDICES 204
Appendix (A) Ethics form approval 204
10. Appendix (B) Questionnaire 205
11. Appendix (C) Invitation to participate in questionnaire survey 212
12. Appendix (D) Focus Group Discussions Questions 213
13. Appendix (E) Invitation to participate in focus group discussion 215

14. Appendix (F) Framework evaluation questions.....216
15. Appendix (G) Invitation to participate in framework validation.....217
16. Appendix (H) Publications and presentations 218

LIST OF FIGURES

Figure 1.1: Map of Nigeria with Yobe State (source: Google, 2016).....11

Figure 1.2: Map of the 17 Local Government Areas of Yobe State (source: Google, 2016). .12

Figure 1.3: Trend of drought occurrence in Nigeria from 1960-2010 (Source: Shiru *et al*., 2018). 13

Figure 1.4: Potiskum Station 25 year rainfall totals (Source: NiMET, 2015). 14

Figure 1.5: Nguru Station 25 year rainfall total (Source: NiMET, 2015).....15

Figure 1.6: Thesis and research structure. 17

Figure 2.1: Future likely increase in severity of extreme weather events (Source: UCS, 2012). 23

Figure 2.2: Map of the USA showing severity of drought in the 1980s and 2002 (Source: Cook *et al*., 2007).....33

Figure 2.3: Areas affected by drought in the Sahel region (Source: UNHAR, 2012). 37

Figure 2.4: Drought Monitor Map (Source: National Center for Environmental Information, (NCEI, 2013).....58

Figure 2.5: Disaster management cycle (Source: Wilhite, 2016). 60

Figure 2.6: The Great Green Wall Project of the Sahara and Sahel (Source: International Tree Foundation (ITF), 2017). 69

Figure 3.1: Weaknesses and strengths of research findings through validations (Source: Straub, 1989).....86

Figure 4.1: 2008 average rainfall and crop production in Yobe State. 107

Figure 4.2: 2009 average rainfall and crop production in Yobe State. 108

Figure 5.1: Flowchart of drought policy implementation in Yobe State. 122

Figure 7.1: Preliminary conceptual framework. 139

Figure 7.2: Social impacts mitigation framework.....143

Figure 7.3: Economic Impacts Mitigation Framework. 148

Figure 7.4: Environmental Impacts Mitigation Framework. 151

Figure 7.5: Integrated Framework. 158

LIST OF PLATES

Plate 1.1: Dryland farm in Gashua (Yobe State) taken on 17/01/2016. 4

Plate 1.2: The impacts of agricultural drought in Romania (Source: BR, 2015).....5

Plate 1.3: Effect of hydrological drought in Southern California (Source: My interesting facts, 2014). 6

Plate 1.4: Effects of socio-economic drought near Nairobi, Kenya (Source: My interesting facts, 2014).....7

Plate 3.1: Researcher with head of Machina Farmers' Association with research team. 77

Plate 3.2: Cross-section of farmers and the research team. 78

Plate 4.1: Irrigation area in North Yobe in Gashua, Bade LGA (Researcher's photo).....98

Plate 4.2: Harvested farmland in Yunusari LGA, Yobe north (Researcher's photo). 100

Plate 5.1: Focus Group Discussion with farmers (age group 25-65) researcher's photo. 113

Plate 5.2: Focus Group Discussion with farmers at Karasuwa Local Government Area researcher's photo (01/10/2016). 115

Plate 5.3: Deputy Directors from the Ministry of Environment of Yobe State with the researcher 119

Plate 5.4: Focus Group Discussion at the Ministry of Environment (05/10/2016). 121

LIST OF TABLES

Table 1.1: States affected by desertification in Nigeria 10

Table 2.1: Effects of drought discussed by multiple authors 28

Table 2.2: List of product losses from the 2009 drought 42

Table 2.3: List of LGAs in Yobe State and estimated lost crop production due to the 2009 drought 43

Table 2.4: Impacts of drought on farms in Australia 52

Table 2.5: Policies established within the Nation Action Plan (NAP) 65

Table 3.1: Comparison of quantitative and qualitative methods 75

Table 3.2: Strengths and weaknesses of quantitative research methods 76

Table 3.3: Advantages and disadvantages of survey 80

Table 3.4: List of Local Government Areas (LGAs) in each region 81

Table 3.5: Advantages and disadvantages of qualitative methods 83

Table 3.6: Data reliability test questionnaire survey in Yobe State 87

Table 4.1: Local Government Areas where data were collected 89

Table 4.2: frequency and distribution of respondents in the three regions within Yobe State 90

Table 4.3: frequency and percentage of employment 90

Table 4.4: frequency and percentage of farming time 90

Table 4.5: Types of farming practised 91

Table 4.6: Knowledge of drought 91

Table 4.7: Number of drought victims 91

Table 4.8: Knowledge of drought victim 92

Table 4.9: Harvest loss due to drought 92

Table 4.10: Effects of drought on social activities 92

Table 4.11: Effects of drought on incomes 93

Table 4.12: Perceived drought events in the past 10 years (2005-2015) 93

Table 4.13: Loss of harvest in the last 10 years (2005-2015) 93

Table 4.14: Effects of drought on food prices 94
Table 4.15: Farmers' perception of causes of drought 94
Table 4.16: Effects of drought on livestock 95
Table 4.17: Numbers of livestock deaths due to hunger 95
Table 4.18: Effects of drought on conflict 96
Table 4.19: Storage of harvest to protect from impacts of drought 96
Table 4.20: Yearly drought coping strategies 96
Table 4.21: Livestock sales compensate impacts of drought 97
Table 4.22: Coping strategies if drought persists 97
Table 4.23: Irrigation as an alternative if drought persists 98
Table 4.24: Drought and it's the dependency on environment 99
Table 4.25: Poverty causes environmental damage 99
Table 4.26: Drought and desertification 99
Table 4.27: Increased desertification 100
Table 4.28: Improved social amenities and welfare 101
Table 4.29: Effects of interventions on drought victims 101
Table 4.30: Drought relief for victims 101
Table 4.31: Would government and private loans mitigate drought? 102
Table 4.32: Cross tabulation of past droughts and regions 102
Table 4.33: Cross tabulation for regions and harvest loss 103
Table 4.34: Cross tabulation for regions and drought coping strategy 103
Table 4.35: Cross tabulation of increased desertification and regions 104
Table 4.36: Cross-tabulation of coping strategy if drought persists verses past 10 years (2005-2015) 105
Table 4.37: 17 LGAs' 2008 and 2009 average rainfall and crop production in Yobe State .106
Table 4.38: Selected impacts of drought in Yobe State 108
Table 4.39: Impacts of persistent drought on livestock 109

Table 4.40: People's response to drought.....109

Table 5.1: Working experience and designations of Ministry of Environment officials.....119

Table 6.1: Review of drought mitigation measures of National Drought and Desertification Policy 130

Table 7.1: Sector frameworks implementation process.....152

ACKNOWLEDGEMENTS

I want show my profound gratitude and appreciation to both Yobe State Government and Yobe State University for funding this research. I believe this piece of research will help mitigate impacts of drought in Yobe State.

It is important to acknowledge individuals that participated, assisted and funded this research work. I want to use this opportunity to thank my family, which includes my wife Hadiza and our two lovely daughters Maryam and Aisha. My parents, whom I cannot thank enough for all the kind love and support their have given me throughout my life (i.e in the persons of Malam Hassan Gana and Aishatu Usman). My siblings and step mum I appreciate all the love and support.

I really want to extend my gratitude and appreciation to my supervisory team for their patience, guidance, kindness, support and trust. I cannot thank Professor Mike Fullen enough. As my DOS he has supported and inspired me throughout this journey. He made the journey worthwhile and enjoyable for me at all times. Dr David Oloke has been very supportive as well in every step of the way. He encourages me every time to push hard and get this work done on time.

I want to thank all my friends in room MI 229 and MI159 for their support. I have to thank all my close family and friends in Nigeria for their undying support at all times. Their names are too numerous to mention.

GLOSSARY

AHP: Analytic Hierarchy Process

AWDN: Automated Weather Data Networks

BMPs: Best Management Practises

CEE: Central and Eastern Europe

CPC: Climate Prediction Centre

DDC: District Drought Committees

EC: European Commission

ECHO: Eradicate Extreme Poverty and Hunger, European Commission Humanitarian Aid Program

ENSO: El Nino-Southern Oscillation

EU: European Union

EWS: Early Warning Systems

EXCO: State Executive Council

FAO: Food and Agricultural Organisation of the United Nations

FG: Federal Government

FGD: Focus Group Discussion

GCM: Global Climate Modelling

GDIS: Global Drought Information System

GDP: Gross Domestic Product

GIS: Geographic Information Systems

GPH: Geopotential Height

GRA: Grey Relation Analysis

GWP: Global Water Partnership

HMNDP: High-level Meeting on National Drought Policy

IDMP: Integrated Drought Management Programme

IPCC: Intergovernmental Panel on Climate Change

JAWF: Joint Agricultural Weather Facility

LGAs: Local Government Areas

MDG: Millennium Development Goals

MEA: Millennium Ecosystem Assessment

MoE: Ministry of Environment

NDC: National Drought Committee

NDDP: National Drought and Desertification Policy

NDMC: National Drought Mitigation Center

NDP: National Drought Program

NEMA National Emergency Management Agency

NGO: Non-Governmental Organisation

NiMET: Nigeria Meteorological Agency

NOAA: National Oceanic and Atmospheric Administration

SPI: Standardized Precipitation Index

SRES: Special Report on Emissions Scenarios

SSA: Sub-Saharan Africa

SST: Sea Surface Temperature

UK: United Kingdom

UN: United Nations

UNEP: United Nations Environment Programme

UNISDR: United Nations International Strategy for Disaster Reduction Report

USDA: United States Department of Agriculture

USA: United States of America

WFD: Water Framework Directive

WMO: World Meteorological Organisation.

CHAPTER ONE: INTRODUCTION

1.1. Chapter overview

Drought is one of the most damaging natural disasters in terms of economic effects and lives lost. For farming communities in Yobe State, Nigeria, who rely solely on rainfall for their activities, the issue of droughts and its negative effects cannot be over emphasised. This research seeks to address the problem of droughts within the context of Yobe State. This chapter introduces the research drought and its types. The chapter also presents the research questions, aims, objectives and structure of the thesis and a new drought definition is also proposed.

1.2. Definitions of droughts

Drought is generally difficult to define and understand, due to its invidious nature. Differences in hydro-meteorological variables, socio-economic factors and high water demand have resulted in multiple definitions (Trambauer *et al*., 2013; Udmale *et al*., 2014; Van Loon and Laaha, 2014). Drought is regarded as a natural phenomenon; and its impacts accumulate slowly over a long period, and it is also considered to be insufficient precipitation that leads to water scarcity, which is triggered by meteorological parameters, such as temperature, precipitation and humidity (AMS, 1997; Trambauer *et al*., 2013). Drought is a naturally recurring climatic feature that occurs in every climatic region (AMS, 1997) and is the deficiency of water or precipitation over a long period (Solh and Maarten, 2014). It is a shortage of precipitation in a particular place over an extended time, which might be weeks, months, years or decades (Solh and Maarten, 2014). There is debate over the definition of drought. Some studies agreed that rainfall deficiency is the main cause of drought (Agnew and Chappell, 1999; Palmer, 1965). Tannehill (1947) argued and used insufficient moisture content, while Solh and Maarten (2014) used deficiency of precipitation. Most countries and regions have their threshold values, for example, the UK Meteorological Office defines

drought as ≥15 days without rainfall, while in Russia it is 10 days if total rainfall is ≤5 mm (Sheffield *et al*., 2012).

Wilhite (2005), stated that drought is the deficiency in precipitation that, when extended to a particular period, is insufficient to meet human demands and the environment, whereas Van Loon and Laaha (2014) defined drought as below-normal availability of water. Most researchers define drought considering the specific situations in an area. Rainfall deficiency is the main factor that leads to the occurrence of drought, whereas its severity depends on timing, distribution and rainfall intensity (Yaduvanshi *et al*., 2015). It is important to consider timing of drought occurrence if there are any delays in the rainy season or reduction in effectiveness (frequency of rainfall within the season) of rain events (Yaduvanshi *et al*., 2015).

Evapotranspiration is one of the important variables that influences drought. It is difficult to quantify evapotranspiration rates to determine drought severity, thus a drought index that computes rainfall is more suitable (Pai *et al*., 2011). However, the primary factor responsible for drought is insufficient precipitation. Mishra *et al*. (2010) and Nwokocha (2017) agreed that lack of universal definition of drought makes it difficult to understand and manage. This research used information gathered in the study area to propose a new definition of drought.

1.2.1. Drought definition in the context of this research

In this research, drought is defined as the shortage of rainfall or water that affects people's livelihood and the environment, both directly and indirectly. Several definitions of drought have not stated both direct and indirect impacts of drought in many places around the world (e.g. Tannehill, 1947; Wilhite, 2005; Trambauer *et al*., 2013; Udmale *et al*., 2014; Van Loon and Laaha 2014). Shortage of water or rainfall affects both people and the environment directly and *vice-versa*. This definition also clearly describes the direction of the study.

Shortage of rainfall in the proposed definition is important, as most drought effects in the study area are due to insufficient rainfall.

1.3. Types of drought

Droughts are complex climatic events that can be characterised by different properties, such as frequency, duration and intensity. They can come in different forms, which also depend on their impacts. For example, when soil moisture or water flow is affected, they have different impacts (Leng *et al*., 2015). All types of drought have different causal factors and characteristics. However, all types of drought are detrimental to both anthropogenic and natural systems (Leng *et al*., 2015). Ecosystems need sufficient water for their functioning (for plants to grow and aquatic organisms to survive) (Yaduvanshi *et al*., 2015). Growing demand for water due to increased population and economic growth makes it insufficient for both systems (Yaduvanshi *et al*., 2015).

Intensity is the level of precipitation shortage in an area, and it is related to the severity of the drought, which is measured by the reduction in precipitation and water level in the hydrological cycle (Van Loon and Laaha, 2014). The duration of drought usually takes at least 2-3 months to manifest, after which it can exist for months, years and even decades. Distribution areas usually affected by intense drought gradually evolve over time (Van Loon and Laaha, 2014). There are four types of drought, namely: meteorological; agricultural; hydrological and socio-economic, which are further discussed below.

1.3.1.1. Meteorological drought

Meteorological drought is a naturally occurring phenomenon that normally starts due to precipitation deficiency caused by climatic factors, and usually causes economic losses (Smakhtin and Hughes, 2007). Meteorological drought is related to water shortage, characterised by abnormal weather conditions, such as low precipitation amounts and high

temperatures (Qin *et al*., 2014). This type of drought is difficult to prevent, but it can be projected and monitored. Deficient precipitation causes drought and it is linked to other types of drought, depending on impacts (Qin *et al*., 2014). Plate 1.1 shows how meteorological drought had affected an area in Yobe State.

Plate 1.1: Dryland farm in Gashua (Yobe State) taken on 17/01/2016.

Human activities and climate change are both responsible for triggering meteorological droughts (Wanders and Wada, 2014). Insufficient precipitation causes agricultural drought, and this translates into hydrological drought through drainage networks (Wanders and Wada, 2014).

1.3.1.2. Agricultural drought

Agricultural drought is defined by the availability of soil moisture content to sustain plants or crop growth and maintain pastures for grazing. Soil moisture content below annual average level decreases crop yield and is described as agricultural drought (Qin *et al*., 2014). This

type of drought has direct adverse effects on crop production and is influenced by several factors, including crop, soil type, soil moisture and irrigation. However, drought intensity is mostly characterised by soil water content and duration (Wang *et al*., 2011) (Plate 1.2).

Plate 1.2: The impacts of agricultural drought in Romania (Source: BR, 2015).

Soil moisture is a component of agricultural drought that plays vital roles in the hydrological cycle. Water storage in soil connects vegetation and subsurface water, making it relevant in precipitation processes (Andreadis *et al*., 2005; Wang *et al*., 2011; Long *et al*., 2013; Thomas *et al*., 2014). During agricultural drought, the main concern should focus on water availability (Qin *et al*., 2014). This drought depends on soil moisture that supports plants after the cessation of precipitation. Normally, after rainy seasons, plants sustain themselves using soil moisture. However, the water holding capacities of soils vary. Soil water relationships are one of the vital characteristics that support plant growth, which simultaneously influence carbon allocation, nutrient cycling, microbial activity and photosynthesis. Soil with low water holding capacity is more liable to drought (Piedallu *et al*., 2011).

1.3.1.3. Hydrological drought

Hydrological drought is defined as insufficient terrestrial availability of precipitation (Van Loon and Laaha, 2014). Normally, this drought is characterised by the loss of water from both subsurface and surface supplies over time (Van Loon and Laaha, 2014). It usually affects the levels of water bodies from average to low, which makes it insufficient to meet human and ecosystem demands. Stream-flow is the most important variable in terms of water quality (Wander and van Lanen, 2013) (Plate 1.3).

Plate 1.3: Effect of hydrological drought in Southern California (Source: My interesting facts, 2014).

Recovering from hydrological drought is usually very slow, considering the time it takes for streams and lakes to recharge, especially where snowpack is the main source of recharge. Increased water consumption has substantially intensified the magnitude of hydrological drought by 10-500%, and increased global drought frequency by ~30% (Wanders and Wada, 2014). Characteristics of hydrological drought (ground-water and stream-flow) will change in

the 21st century due to climate change (Wander and van Lanen, 2013). There will be increased hydrological drought duration and severity, and greater impacts of events will be evident, including on ground-water and stream-flow. There is, therefore, an urgent need for water resource managers to design proactive measures to curtail these issues.

1.3.1.4. Socio-economic drought

Socio-economic drought is insufficient precipitation to meet human and environmental demands, it is triggered by human activities and elements of other types of drought (hydrological, meteorological and agricultural) (Wilhite, 2005). Drought causes environmental, economic and social damage in arid and semi-arid regions during prolonged episodes (Wilhite, 2005) (Plate 1.4).

Plate 1.4: Effects of socio-economic drought near Nairobi, Kenya (Source: My interesting facts, 2014).

1.4. Background of the study

The influence of growing water demand and global climate change has caused concerns about increasing drought conditions in the future. There is possibility that climate change will affect food production which in turn affects peoples' livelihood (IPCC, 2014). Rain-fed farming is the dominant source of food production and means of livelihood for many poor rural farmers in Sub-Saharan Africa including Nigeria (Cooper *et al*., 2008). Peasant farmers in the Manga Grasslands of north-east Nigeria depend largely on agriculture for their livelihoods and they have been affected by recurrent drought since the 1970s (Alhassan *et al*., 2003). Drought frequency has also challenged their traditional farming systems in north-east Nigeria. People in the region are mainly subsistence farmers and nomadic livestock herders, hence the agriculture based rural economy of the area (Alhassan *et al*., 2003). Severe drought has struck the Sahel region in the 1970s leaving millions of people in starvation and Nigeria is one the countries in the region affected by the 'Great drought' in the 1970s (Mortimore, 1989).

Accurate drought assessment is important for planning and management of the environment, water resources and ecosystems (Mishra *et al*., 2015). UNSIDR (2011) and Shiferaw *et al*. (2014 reported that there is urgent need to reduce the vulnerability of countries to climate variability and the threats posed by drought, especially those in drought prone areas. Investigating the level of impact would improve method of mitigation (Mishra *et al*., 2015). However, in recent years there has been progress in developing new drought concepts, advances in drought modelling, monitoring strategies, improved impact assessments and mitigation strategies (Mishra *et al*., 2015). Despite the progress and improvements, remaining key challenges include the transfer of methodologies and strategies between regions (Mishra *et al*., 2015). This is usually due to the differences in local hydro-meteorological features and socio-economic conditions (Mishra and Singh, 2010). Drought has different mitigation

strategies, but they all aim to reduce water shortages, improve socio-economic livelihoods and reduce environmental damage. Drought mitigation strategies can be both reactive and proactive (Bradford, 2000). Proactive measures of drought mitigation are strategies/measures taken prior to droughts as part of planning and preparation. Reactive measures are strategies taken after droughts (Bradford, 2000). Priority of drought mitigation differs between countries, depending on the sector and aspect most affected. This can also be monitored and assessed through previous experience, pre-planning, types of drought and severity. Effective responses to droughts situations require appropriate institutional frameworks, which assists in decision-making processes (HMNDP, 2013). Efforts in Nigeria have been reactive and are planned at governmental level without involving other stakeholders during planning (Nwokocha, 2017, Section 2.12.2).

1.4.1. Statement of problems

Farming is mainly how people cater for their basic needs in Yobe State. Poverty and lack of jobs are problems in the State making farmers vulnerable to climate variability (YBG Report, 2010). Drought affects incomes, agricultural production and causes serious environmental problems that are difficult to recover from. Drought has been poorly documented in recent years and the impacts are increasing in magnitude and complexity (Abdullahi *et al*., 2006). Drought and desertification are more pronounced in north-eastern Nigeria (Olagunju, 2015; Elijah *et al*., 2017). Nigeria is considered one of the world's most deforested countries, with losses of ~55.7% of the primary forests which is nearly half forest in the country. This can be attributed to poverty problems in the country. The north-east region of the country has the highest poverty rate in the country especially the states severely affected by desertification and drought (NPC, 2006; Olagunju, 2015). The north-east region has a poverty rate of 76.3% compared to the mean national 69.2% relative rate (NPC, 2006). About 80% of people in

northern Nigeria are involved in farming, especially crop production and pastoral farming (Macaulay, 2014).

Yobe State is one of the most severely affected by drought and is among the nine drought and desertification frontline States in Nigeria (Olagunju, 2015). Nigeria loses ~351,000 hectares of land annually due to desertification and southward movement of sand (Nwokocha, 2017). It is estimated that the southward movement of sand is ~0.6 km per year and Yobe State has lost ~25,000-30,000 hectares annually in the last decade (Nwokocha, 2017). Drought in the north-east region plays significant role in increased desertification in the area (Musa and Shaib, 2010; Olagunju, 2015; Terhile, 2017). Farmers in Yobe State were chosen as the sample group due to their vulnerability to drought (Abdullahi *et al*., 2006). Among the six north-east States Borno and Yobe States are the most severely affected by desertification (Olagunju, 2015). Table 1.1 shows the States most affected by desertification in northern Nigeria. Some States in the north-west are also severely affected, including Katsina, Jigawa, Sokoto, Kebbi and Zamfara.

Table 1.1: States affected by desertification in Nigeria

S/no.	States	Geographic region	Rate of desertification
1	Sokoto	North West	Severe
2	Zamfara	North West	Severe
3	Katsina	North West	Severe
4	Jigawa	North West	Severe
5	Kano	North West	Moderate
6	Kebbi	North West	Severe
7	Kaduna	North West	Moderate
8	Borno	North East	Severe
9	Yobe	North East	Severe
10	Bauchi	North East	Moderate
11	Gombe	North East	Moderate
12	Taraba	North East	Moderate
13	Niger	North Central	Moderate
14	Plateau	North Central	Moderate

(Source: Olagunju, 2015).

1.4.2. Study area

Yobe State is among the 36 states of Nigeria and covers 47,153 km^2 is Latitude 10.578-13.377^0 N and Longitude 9.654-12.689^0 E (Figure 1.1) (YSG Report, 2010). Yobe State had a population of 2,321,339 million people at the last (2006) census (NPC, 2006). In the study area, desertification and drought are the main environmental issues and the region has long dry seasons, recurrent drought, skeletal soil and sparse vegetation cover (Dabi and Anderson, 1999; Obi, 2012). Yobe State shares boundaries from the west with Jigawa and Bauchi States, Gombe and Borno States to the south-east and an international boundary of 323 km with the Niger Republic to the north (YSG Report, 2010). Yobe State has 17 Local Government Areas (LGAs) distributed within three geographic regions (South, East and the North). The LGAs are Bade, Bursari, Damaturu, Fika, Fune, Geidam, Gulani, Jakusko, Karasuwa, Nangere, Nguru, Potiskum, Tarmuwa, Yunusari, Gujba, Machina and Yusufari (Figure 1.2).

Figure 1.1: Map of Nigeria with Yobe State (source: Google, 2016).

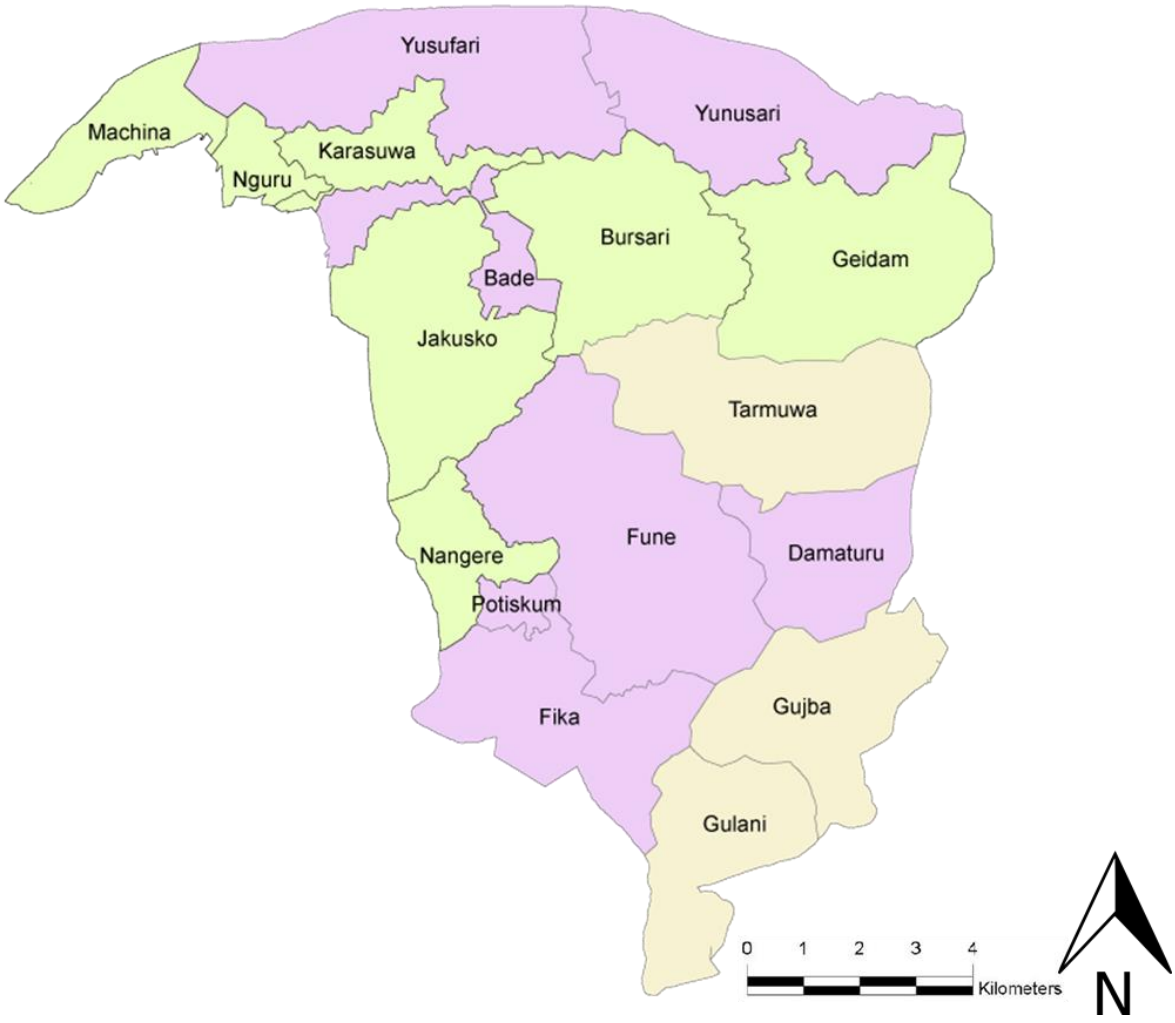

Figure 1.2: Map of the 17 Local Government Areas of Yobe State (source: Google, 2016).

1.4.3. Rainfall distribution in Nigeria and Yobe State

Drought monitoring systems are important for both short and long-term drought risk management using rainfall (Andreu *et al.*, 2013). Temperature, rainfall and Standard Precipitation Evaporation Index (SPEI) were used to assess increase in drought frequency in Nigeria (Shiru *et al.*, 2018). Temperature and rainfall data from 1961-2010 were also collected. Findings predicted increased temperatures, evaporation and decreased rainfall to drought occurrence. Figure 1.3 shows the increase in drought in Nigeria which presented trends of drought occurrence from 1960-2010, which shows significant increase over the years (Shiru *et al.*, 2018).

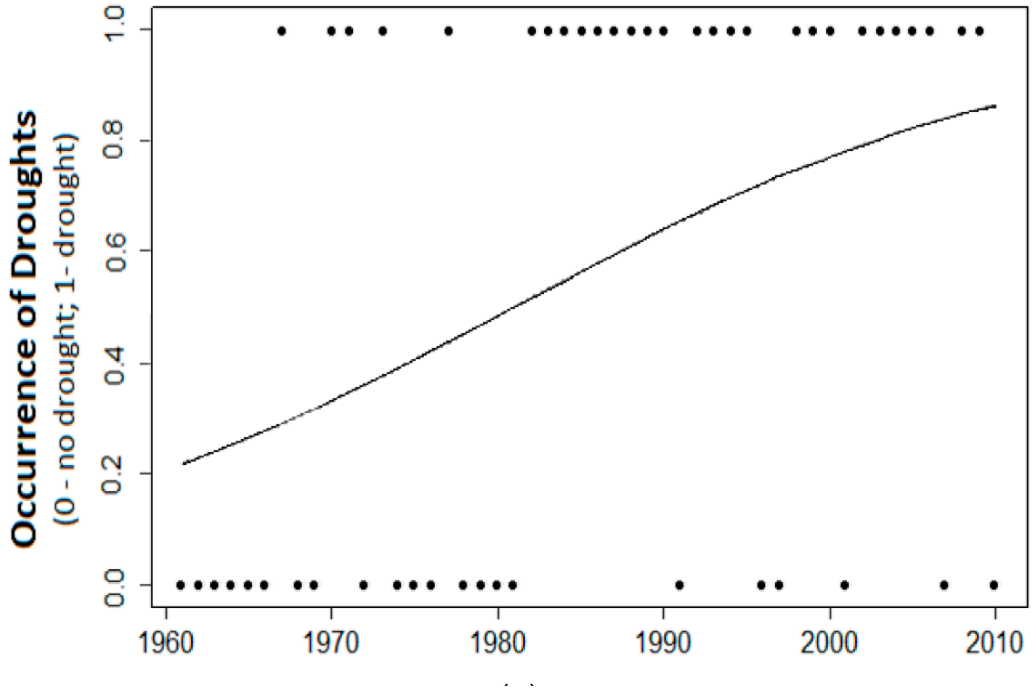

Figure 1.3: Trend of drought occurrence in Nigeria from 1960-2010 (Source: Shiru *et al*., 2018).

Oguntunde *et al*. (2011) examined rainfall patterns in Nigeria from 1901-2000 and found out there was a decrease in rainfall during the last part of the 20th century. Oguntunde *et al*. (2011) used Standardized Precipitation Index to estimate the departure. There was 57% decrease in rainfall from 1961-1990, but there was only 7% decrease from 1930-1960. Rainfall distribution across Nigeria is highly variable, in the north-east average value are ~400 mm per annum and ~2500 mm per annum across the south-south (Oguntunde *et al*., 2011). Average annual rainfall along the coastline in southern Nigeria is ~3,500 mm per annum <600 mm per annum in the Sahel region of the north-east (FME, 2012). The studies of Oguntunde *et al*. (2011) and Shiru *et al*. (2018) showed that there is significant decrease in the amount of rainfall in Nigeria over the last five to six decades. Rainfall is unevenly distributed in the north-east (Oguntunde *et al*., 2011). There has been decreased rainfall pattern in the West African semi-arid region during July, August and September from1960-1990 with annual average rainfall of 150-200 mm (Sarr, 2012). Annual precipitation in the Sahel is between 200-700 mm (Agnew and Chappell, 1991).

It was important to assess the average rainfall in Yobe State. Data were collected from the Nigeria Meteorological Agency (NiMET). A 25 year (1990-2015) record of Yobe State rainfall data was collected. NiMET has only two conventional weather stations in Yobe State, one at Nguru, which is in the north and Potiskum in the south. The distribution of rain is uneven across the two stations, rainfall received for 25 years varied between 80-300 mm a year over 25 years at Potiskum Station (Figure 1.4) and 40-190 mm over 25 years at Nguru Station (Figure 1.5). According to the data received from NiMET rainfall events in Yobe State is mostly between June–September every year, but it varies at times and starts in May. The data further showed if the rainfall starts in May it creates gap for weeks before having consistent rainfall.

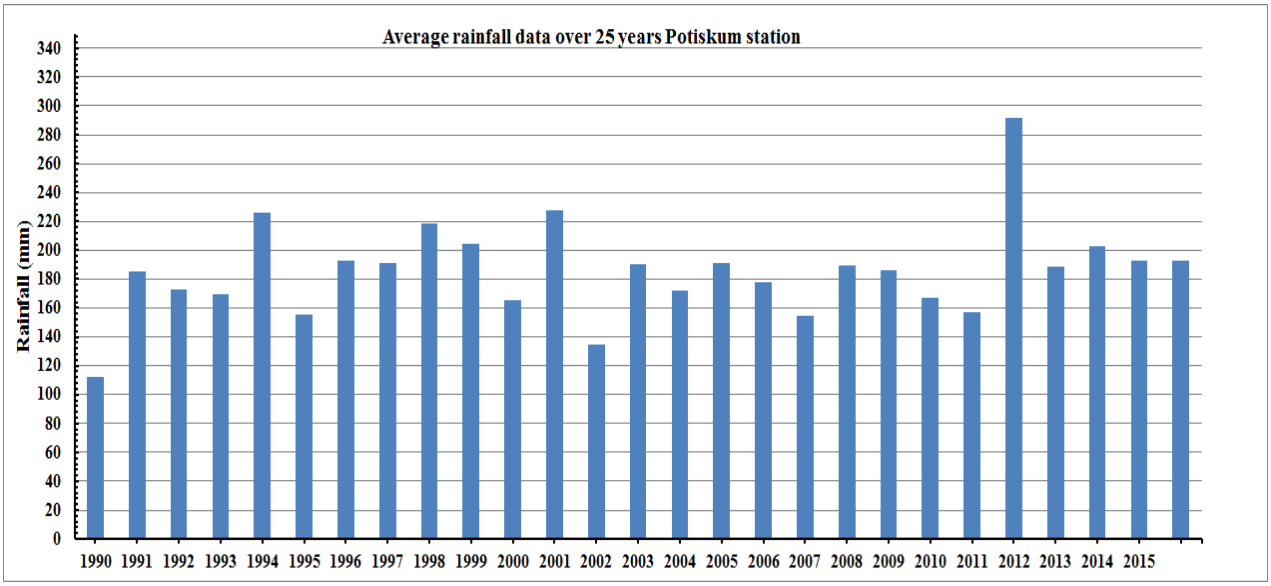

Figure 1.4: Potiskum Station 25 year rainfall totals (Source: NiMET, 2015).

Yobe south receives more rainfall than Yobe north. The data showed that in 1994 and 2012 both stations recorded their highest rainfalls. Nguru Station recorded 180 and 185 mm, respectively, and 240 and 300 mm respectively for Potiskum. Yobe State receives about half of the rainfall of Sahel region in 25 years (1990-2015) and receives less than quarter of the national average (Oguntunde *et al.*, 2011; FME 2012; Shiru *et al.*, 2018).

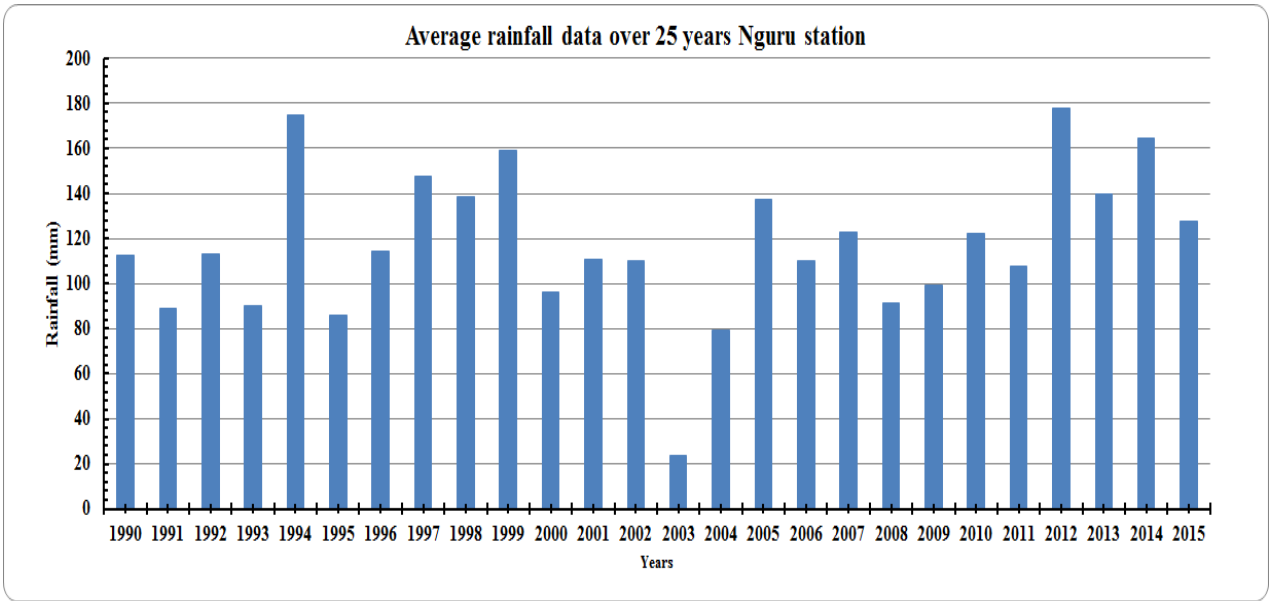

Figure 1.5: Nguru Station 25 year rainfall total (Source: NiMET, 2015).

1.4.4. Research questions

The following are posed

1. How does drought affect the livelihood of farmers in Yobe State?
2. How does drought coping strategy affect the environment of Yobe State?
3. Which parts of the State are most vulnerable to drought?
4. What are the possible ways to mitigate drought effects at local levels before intervention or support?
5. What are the government strategies and how can they be improved?

1.5. Research aims

This research sought to investigate on drought in Yobe State and make recommendations to mitigate impacts of drought. This will help to develop a comprehensive drought mitigation strategy for Yobe State. In order to achieve that, two research aims and five objectives were proposed. The aims and objectives of this research are:

1.5.1. Aim One

Assess the damage caused by drought to farmers' livelihood and the environment.

Objectives

In order to achieve this research aim, three objectives were framed.

1. Investigate social response at community level in order to help mitigate drought, this is to understand how farmers respond to drought traditionally. It would also help in organising local mitigation strategies to make farmers more self-reliant.
2. Investigate the environmental effects of drought coping strategies. In order to reduce environmental degradation caused by drought in Yobe State. This will be conducted through literature review and empirical studies.
3. Investigate spatio-temporal rainfall trends in Yobe State to understand which part of the State receives less rainfall. The analysis was based on, 25 years (1990-2005) of rainfall data collected from the Nigeria Meteorological Agency (NiMET).

1.5.2. Aim Two

- To develop a framework for the amelioration of drought in Yobe State as a planning and management tool for the State Government and other stakeholders.

Objectives

In order to achieve this research aim, two objectives were framed.

1. Produce frameworks that can be used by stakeholders to mitigate impacts of drought. This could reduce the cost of drought mitigation for both communities and government by using appropriate drought mitigation measures.
2. Assess and evaluate the robustness and transferability of the proposed frameworks. This will be conducted by collecting empirical data from the framework users.

1.6. Thesis structure

A flowchart of the research structure is presented in Figure 1.6. Chapter 1 comprises of drought definitions and background of the study. Chapter 2 collated information on effects of drought and global impacts of climate change.

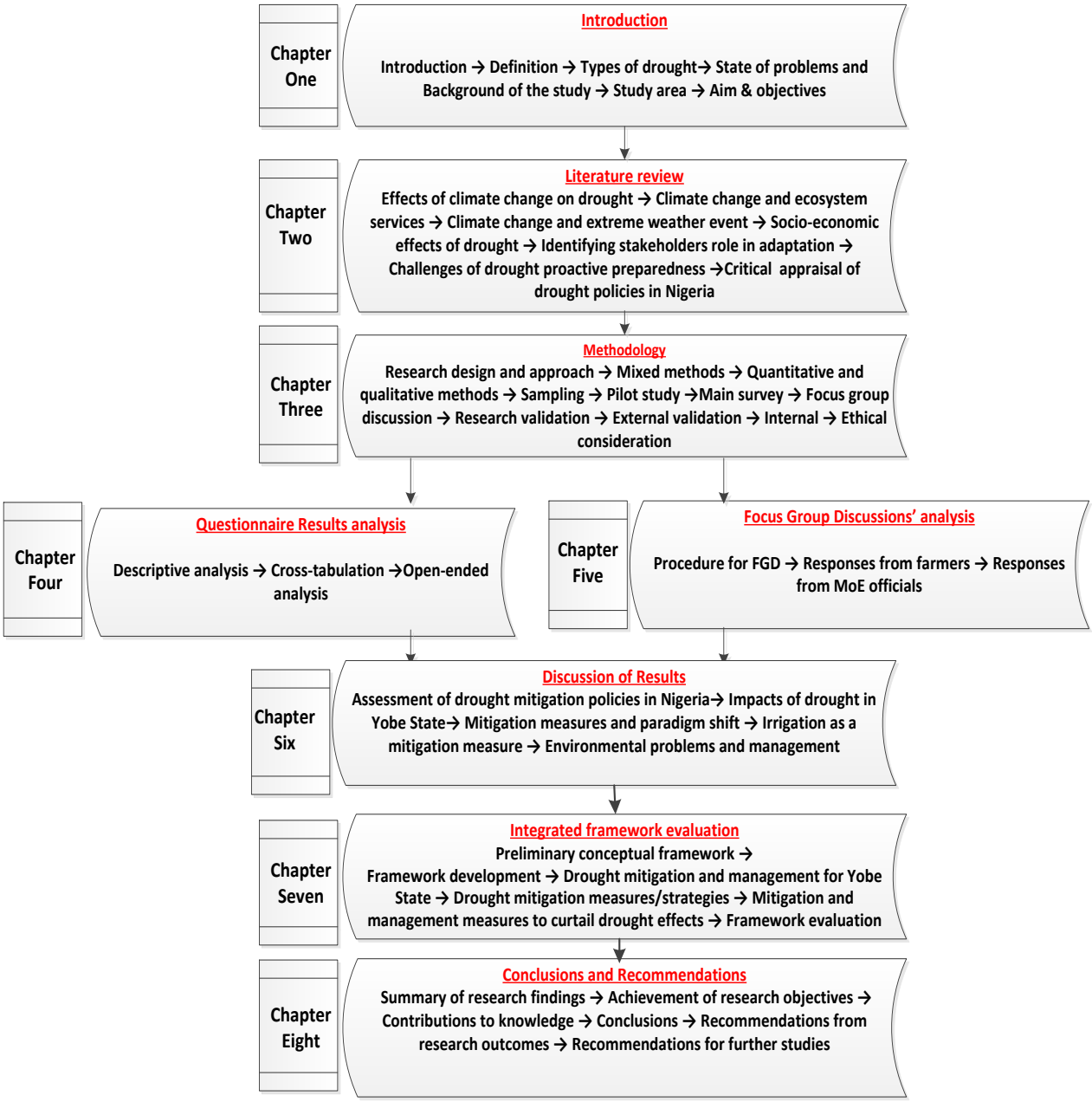

Figure 1.6: Thesis and research structure.

All aspects proposed in the preliminary conceptual framework were used to gather information on drought in Yobe State. The methodologies used are presented in Chapter 3. All collected data are presented in Chapters 4 and 5. The assessments provided information on drought in Yobe State, where mitigation and management frameworks were developed based on findings from Chapters 4 and 5. Discussion of major results from both assessments is presented in Chapter 6. Chapter 7 presents the preliminary conceptual framework of the Study. Based on the findings of the empirical studies sectoral frameworks and integrated framework were designed for Yobe State. In order to ensure the sustainable application of the frameworks, a before-use evaluation was conducted to determine the feasibility of the frameworks to mitigate drought impacts (Chapter 7). Conclusions and recommendations were made, which also highlighted the study's contribution to knowledge (Chapter 8).

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter discusses the global effects of climate change and drought. An overview of processes of adaptation to climate change and strategies of drought mitigation in selected countries and regions around the world are presented. It emphasises the situation in Africa, especially northern Nigeria, where drought has caused environmental destruction, decreased food production, famine and social deprivation. Past and current policies and efforts made by Nigerian Governments are reviewed to identify research gaps.

2.2. Effects of climate change

Changing climate is leading to rising sea-levels and increased frequency of weather extreme events, such as drought, floods and severe storms. The atmospheric greenhouse increase is due to human activities (carbon emission), thus changing the concentrations, which alters the climatic system (IPCC, 2014). There will be probably increased rainfall variability and drought severity in much of the world (Kusangaya *et al.*, 2014; Mosley, 2015). However, climate changes naturally, but the increase in greenhouse gases triggers more rapid changes and influences the occurrence of extreme climatic events. Drought frequency will probably increase due to less rainfall and increased evaporation, which is mainly because of increased temperatures (Sheffield *et al.*, 2012).

Climate change is considered to be one of the major challenges of the 21st century (IPCC, 2014). Observations for over 157 years showed that global surface temperatures have risen (Clark *et al*., 1999; Savo *et al*., 2016). The past century has witnessed two phases of increased atmospheric temperature from the 1910s–1940s by 0.35^{0}C and from 1970-recent years by 0.55^{0}C. Drought assessment based on decreased moisture showed that there will be recurrent drought (Burke *et al*., 2006). Sheffield *et al.* (2012) used other climate variables (wind speed, humidity, moisture and temperature) to show similar trends of possible recurrent

drought. However, changes due to the changing climate are spatio-temporally highly variable. Extreme events will increase climate-related disasters, which will in turn have devastating impacts on social well-being, habitat disruption and economic hardship (Kusangaya *et al*., 2014). These impacts every part of the natural environment and human well-being and can lead to loss of life, losses of agricultural production, species extinction and water crises (Kusangaya *et al*., 2014).

Climate change predictions indicate that Earth will be generally drier and warmer in the future (Solh and Maarten, 2014 and Olmstead, 2014). Climate change can have both long-term and short-term variability around the world. Change in future climate is projected to affect most climatic variables, such as temperature, precipitation, humidity, water discharge and availability (Arnell *et al*., 2011; Davies and Simonovic, 2011; Tsanis *et al*., 2011). This is due to economic and population growth, land use and pollution (Koutroulis *et al*., 2013). Uncertainty of water availability and quality due to climate change and pollution threatens both environmental and social aspects, including tourism, agricultural production and biodiversity (Olmstead, 2014). It is an important task for scientists and water resource managers to initiate adaptation measures.

Numerous studies have emphasised the issue of climate change and its impact on many sectors and aspects of the environment and economy (Olesen and Bindi, 2002; Mirza, 2003; IPCC, 2007; Gosling, 2013). For example, Europe has experienced increased mean surface temperature over the last century, of ~0.8^0C (Charlesworth, 2010). Global Climate Modelling (GCM) simulated annual temperatures in Europe, which shows that the continent has warmed at the rate of 0.1–0.4^0C in the second half of the 20^{th} century (Olesen and Bindi, 2002). However, despite the projected rise in temperature in Europe, it is expected that southern and north-east Europe will experience most temperature increase (Parry, 2000; Hellmuth *et al*., 2007; Savo *et al.,* 2016).

Considering the issue of climate change globally, it is important to have an overview of future drought projections, including both the impacts on humans and the environment as a measure for securing future water and food security (Wanders and Wada, 2014). Severe impacts of drought historically showed that there is a need for scientists and society to improve knowledge and understanding of drought mechanisms for better preparation, mitigation and management. Clemens *et al*. (2016), described adaptation to climate as the changes or adjustment to systems in response to unexpected climate stimuli and their impacts. The study stated that adapting to climate change has been a challenge in recent years. Stabilising global carbon emission through proper international frameworks will help mitigate the impacts of global warming, considering a possible temperature increase of $\sim 4^0$C by 2100 (Adger and Barnett, 2009; Fussel, 2009; Smith *et al*. 2009). Many organisations, groups and governments are now taking proactive measures (Smit *et al.*, 2000; Adger *et al.*, 2005). Adaptation can be encouraged by many actions, for example, protecting economic well-being and improving people and environmental safety to meet sustainable growth (Adger, 2003). Middle and low income countries are vulnerable and have limited resources and measures for climate change mitigation (Lindseth, 2004; Adger *et al.*, 2005).

2.2.1. Climate change and ecosystem services

Ecosystems provide humans and other organisms with numerous services, including food, energy, water and habitats (Desanker *et al*., 2001; Gosling, 2013). Ecosystem services are divided into three categories; provisioning, regulating and supporting services Millennium Ecosystem Assessment, (MEA, 2005). Provisioning are the basic services required by living organisms, such as water, energy and food which are provided by the ecosystem. Supporting services include water cycling, nutrient cycling and habitat provision. Regulating services provide carbon sequestration, air quality, temperature and coastal wave defence (MEA,

2005). Climate change has the ability to cause acute sudden environmental changes which directly impacts ecosystem services (Galaz *et al*., 2008).

Drought affects forests, deserts and decreases the number of species. All these are due to decreased precipitation and resultant drought stress. Healthy ecosystems play important role in improving agricultural production and increase resilience to change (FAO, 2018a). Most of poor farmers depend directly on the environment, especially biodiversity, for survival. Changes or loss in biodiversity will affect their livelihoods (FAO, 2018a). There is a need to emphasise the importance of ecosystem services in order to maintain them and thus cope with future climate change (Galaz *et al*., 2008; Gosling, 2013).

2.2.2. Climate change and extreme weather events

Droughts usually set in gradually, which is different from other natural disasters, where their onset and cessation are usually rapid (Muller, 2014). The change in climate trends has made developing countries vulnerable to extreme weather events, with attendant economic loss and decline in socio-economic activities (Mirza, 2003). It was estimated at the beginning of the 21st century that annually, extreme weather events have cost developed countries over $35 billion in the early 2000s, this is almost 10 times the cost to developing nations (Freeman, 2001). Developed nations have lower impacts than developed nations, due to better infrastructure, social welfare and economic benefits (Mirza, 2003). Accessibility to infrastructure and social welfare tends to reduce the impacts of such disasters (Wilhite, 2002). In some situations, due to the presence of infrastructure and welfare, the impacts are not directly felt by people (Wilhite, 2002). Figure 2.1 shows the likelihood of increases in the severity of weather events. Other naturally occurring disasters largely have structural impacts, which directly destroy properties and ecosystems (Wilhite, 2002).

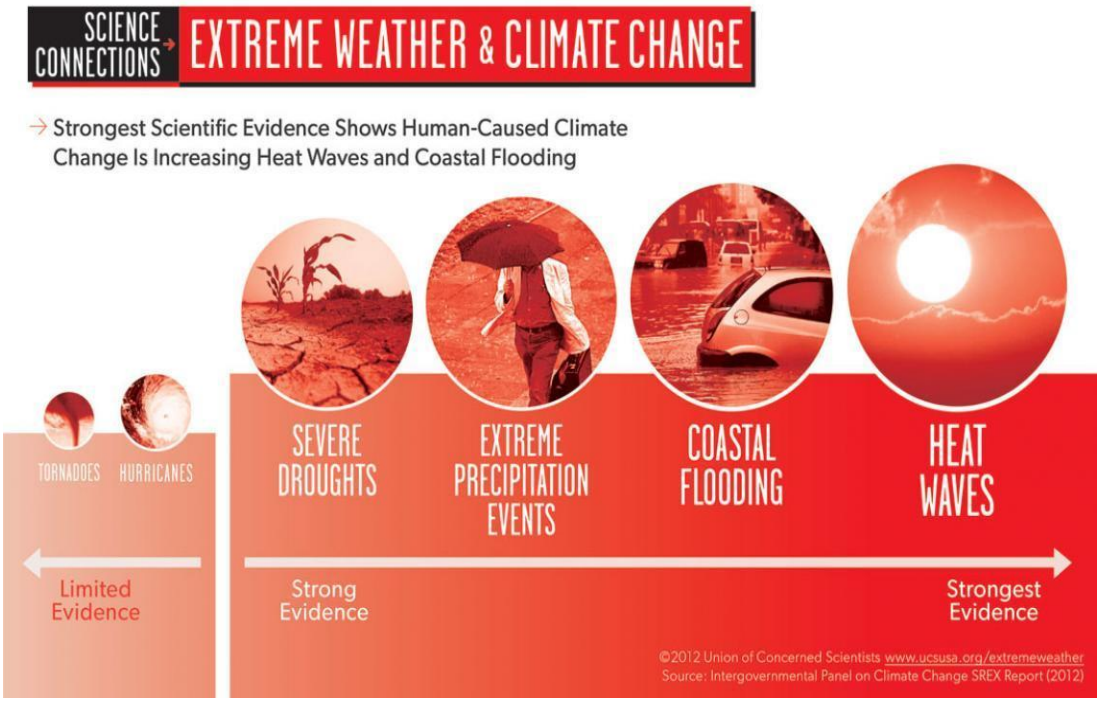

Figure 2.1: Future likely increase in severity of extreme weather events (Source: UCS, 2012).

2.2.3. Impacts of climate change in Nigeria

Recently, Nigeria is experiencing the negative impacts of climate change, which affected the welfare of millions of people, especially farmers (Olaniyi *et al*., 2014). In the arid zones, droughts are getting worse and climate uncertainty is growing, climate change is an unprecedented and threat to food security. Arid and semi-arid areas in northern Nigeria are becoming drier, while the southern part of the country are getting wetter, global warming means that many dry areas are going to get drier and wet areas are going to get wetter (Atilola, 2010).

Droughts and floods are some of the major impacts of climate change in the country. This problem needs proper attention and mitigation considering that most people depend on agriculture in Nigeria (Olaniyi *et al*., 2014). Rivers, lakes, hydro-electric power stations are drying up and have witnessed low level capacities over the last few years (Olaniyi *et al*., 2014). The impacts are evident in northern Nigeria, as drought severity and aridity are

increasing which threatens food security (Atilola, 2010). Agriculture contributes substantially to Nigeria's GDP, where most of the rural population (70%) relies on agriculture for livelihoods (Olaniyi *et al*., 2014). Changes in climate and weather patterns have had devastating impacts on these peoples' lives (Idris, 2011). These are further aggravated by over-grazing, over-exploitation, deforestation, poor irrigation practises, resources conflict, lack of food security and losses in fauna and flora (Idris, 2011).

2.3. Vulnerability to drought

IPCC (2001; 2014) defined vulnerability as the level to which a system (natural or social system) will resist damage from climate change. Vicente-Serrano *et al*. (2012) defined vulnerability to drought as the ability of a region to withstand drought. Adaptive ability to vulnerability is how quickly systems adjust to climate change. Vulnerability of individuals is based on their capability to withstand exposure, stress and their coping strategy (Perkins, 2001). Resistance means the ability to slow and reduce the impacts of drought, whereas resilience refers to capacity of a system to recover from drought. Antwi-Agyei *et al*. (2012) identified factors such as poor soil, poor water management, poverty, rural vulnerability, population growth, changing consumption patterns, climate variability and land use change as factors that can exacerbate the impacts of drought. Population growth and over-exploitation of natural resources compromise adaptation to drought in Africa, due to social and economic stresses on communities (Antwi-Agyei *et al*., 2012). Vulnerability level has increased amongst African communities over last few decades (Wilhite, 2007; Vicente-Serrano*et al*., 2012). Furthermore, responses vary as drought impacts also differ spatially and temporally in every region (Wilhite, 2007).

The United Nations International Strategy for Disaster Reduction Report UNISDR (2004) categorised vulnerability factors into 3 environmental, social and economic.

- Environmental factors are those that describe the condition of the environment in an area.
- Social factors describe the state of well-being of individuals, groups, the population and communities, which is also known as the non-economic factor.
- Economic factors describe the state of the economy in the region (UNISDR, 2004).

Assessment of drought vulnerability is complex (Kim *et al*., 2015). Guiquin *et al* (2012) investigated vulnerability of agriculture to drought in 31 provinces and cities in China. The study employed the Grey Relation Analysis (GRA) method to identify factors influencing agricultural drought and translated them into quantitative indicators. The studies found that the South-east coast of China had least vulnerability to agricultural drought than central areas, due to high precipitation and irrigation. The western area had high vulnerability to agricultural drought, due to low precipitation and excessive irrigation.

The results show that farmers' vulnerability is influenced by social, economic, infrastructural and psychological factors. Understanding vulnerability to drought is complex, because it depends on socio-economic and biophysical indicators (Shiferaw *et al*., 2014). The word 'vulnerability' is used in different academic disciplines, depending on the context (Zarafshani *et al.,* 2012). Factors considered while studying vulnerability to drought, include population, policy, technology, social behaviour, land use patterns, water use and economic development (Wilhite and Svoboda, 2000; Naumann *et al*., 2013). In this research, vulnerability is used as a term to determine farmers' exposure to drought.

2.3.1. Adaptive strategies

Drought is not usually an instant killer, as it manifests slowly and develops over time. There are different ways to cope with drought. For example, short-term measures include supply of drinking water to affected victims, but long-term strategies are migration and changes of

livelihood are considered as adaptation strategies. However, drought coping strategies vary according to culture, traditions and socio-economic situation (Singh and Byjesh, 2014). Livestock, use of crop varieties, crop mix and land changes are ways rural communities in semi-arid regions cope with drought (Alam, 2015).

2.3.2. Impact of drought on income and coping strategies in semi-arid regions

People in rural communities of developing countries are at risk of income shocks due to effects of climate variability and extreme events (Kinsey *et al*., 1998). Fluctuation of income leads to unstable agricultural output, which in turn affects crop prices and issues such as pest and crop disease (Kinsey *et al*., 1998). Farmers in Yunusari LGA in Yobe stated that drought increases prices of food in their local market, making it unaffordable for them to buy food (Gbahabo, 2011). These situations leave poor households in most communities in debt, due to increased crop prices to compensate for the income shortfall.

In the Sahel, the usual mechanism people use is livestock as a buffer, to compensate lost income and food shortages (Fafchamps *et al*., 1998). The study suggests that not all livestock sales compensate for income shock and crop losses. During the worst drought episodes in semi-arid areas, some households and farmers sold their livestock to compensate for income shock, but only 15-30% of the loss can be compensated (Fafchamps *et al*., 1998). Throughout human history there have been extreme conditions and people usually find ways to cope (Tideman and Khatana, 2004). There are different mechanisms to deal with drought, which are adaptive strategies or risk reduction. Risk coping strategies are divided into 2: *ex-ante* and *ex-post* (Pandey *et al.*, 2007).

Ex-ante: Risk coping strategy mitigates risk of income shortfall due to climatic variability. It is also referred to as ‘income smoothing strategy’ or ‘reducing risk exposure’. This is designed to reduce risk, but it is costly in terms of forgone opportunities. Farmers living in

drought prone areas modify their production strategy to provide self-insurance during drought or shortfalls (Shiferaw *et al*., 2014).

Ex-post: Risk coping strategy is to reduce losses that occur due to shortfall in agricultural production, which reduces consumption by farmers' if they are unable to meet the deficit by other means. This is to control shortfalls in agricultural output (Pandey *et al*., 2007; Shiferaw *et al*., 2014). Cash saving, borrowing, liquidating assets, relying on charity and permanent migration are the usual mechanisms to cope with production shortfalls. For this strategy, farmers are expected to save during normal and better crop yield periods to meet consumption needs when shortfalls occur (Pandey *et al*., 2007).

2.4. Socio-economic effects of drought

Many studies have shown that drought has not been well documented and it appears that the magnitude and complexity of it impacts are increasing (Wilhite and Pulwarty, 2005; Feyen and Dankers, 2009). Droughts have different socio-economic effects on humans, which include lack of labour, decreased agricultural productions, diminished human health and increased prevalence of diseases. However, social characteristics also vary according to regions, traditions, cultures, households and individuals and adapting to impacts of drought depends on social responses (Wilhite *et al*., 2007). In many places, the impacts of drought can be diverse and its effects are either direct or indirect (Gutierrez *et al*., 2014). Droughts have caused more environmental refugees in recent years than any other time in human history. This disaster has caused more deaths than any other natural disaster in the 2nd half of the 20th century (Vicente-Serrano *et al*., 2012). Socio-economic activities and environmental degradation move simultaneously, for example, over-exploitation of natural resources due to an extreme climate event is an alternative coping strategy (Shiferaw *et al*., 2014). These activities include productivity loss, increased forest fire hazards, reduced water levels, increased livestock and wildlife mortality rates and damage to wildlife and fish habitats.

Exploitation of natural resources and habitat increases when there is reduced farm output, unemployment, famine and extreme events, such as drought and hurricanes (Shiferaw *et al*., 2014). Indirect impacts of drought include environmental degradation and reduced incomes, which affects livelihoods through the prices of both livestock and crops. Indirect effects of drought could be larger than direct impacts (Zimmerman and Carter, 2003; Holden and Shiferaw, 2004). Droughts account for only 5% of natural disasters, but the total losses caused are ~30% compared with other natural disasters (Wang *et al*., 2014). In contrast, Keshavarz *et al.* (2013) stated that 22% of damage caused by natural disasters is from drought and 33% of persons affected by disasters were caused by drought. Effects of climate change on drought and their implications are listed in Table 2.1. The socio-economic aspects include increased work load, decreased income, malnutrition, poor access to health services, migration, emotional impacts (depression and frustration), poverty, reduced life quality and conflicts over land and water resources (Alston and Kent, 2008).

Table 2.1: Effects of drought discussed by multiple authors

Authors	**Implications**
Shukla & Wood, 2008	Effects of droughts events are mostly related to hydrological conditions, which are reduced ground water level and low streamflow.
Agnew & Chappell, 1999	Due to changing climate, it is important to understand drought trends, previous studies have showed frequent recurrent drought might change drought trends in the future.
Msangi, 2004	Extent of drought severity in countries with land and resource degradation is more detrimental; whose economic welfare and social service systems cannot resist the impacts. Land and resource degradation include destroying fragile environment, soil erosion, destruction of vegetation cover and over-cultivation of agricultural land. These environmental problems in such areas give people limited options and few coping strategies to deal with drought.
Edossa *et al*., 2010	Recently, some countries have faced rainfall shortages, including Zambia, Tanzania, Namibia, Kenya, Somalia, Zimbabwe and South Africa Droughts and land degradation affect and threaten the livelihood of many people living in rural areas in these countries.
Shen *et al*., 2007	Severe drought has devastating impacts on socio-economic aspect of human life and the environment.
Burke *et al*., 2006; Blunden *et al*., 2011	Since the 1970s, droughts have increased in number and have affected many regions. This has increased the extent of extreme drought events around the world from 1-30% during the 21st Century. It is believed that severity, intensity, frequency, duration and distribution of drought will increase.

2.4.1. Famine and drought

In semi-arid regions, famine is triggered by prolonged drought (Speranza *et al*., 2008). Drought and famine persists in Sub Saharan Africa. Water scarcity and insufficient vegetation also contributes to drought and famine. Most famine or food crises are associated with rural livelihoods and living conditions (Sen, 1999). Rural communities struck with prolonged drought find it difficult to produce sufficient crops to meet immediate demands (Antwi-Agyei *et al*., 2012). This situation makes communities unable to build a buffer for future drought resistance. Rural communities in Sub Saharan Africa are food insecure, regardless of whether drought occurs or not, but drought further worsens conditions (Speranza *et al*., 2008; Antwi-Agyei *et al*., 2012). Drought in northern Nigeria led to famine in 1914, 1927, 1942 and in the 1970s (Mortimore, 1989; Gbahabo, 2011). The 1940s famine led farmers in the north-east to live on cassava for food and at the time food prices increased from £23 to £26 against good harvest period (Gbahabo, 2011).

2.4.2. Effects of drought on conflict

One-third of the Sub Saharan Africa population live in drought prone regions (UNEP, 2008). Population increase in the region will worsen the projected drought conditions. Increased drought severity in Africa can cause social conflicts and civil war (Burke *et al*., 2009). Scarcity of natural resources increase and intensify competition on the remaining limited resources, where there is tendency to ignite conflicts among communities in affected areas (Ghai, 1992).

Drought can instigate conflicts and civil war scientific evidence have not put justifiable facts on assessing the issue and stressed the need to consider both scientific and social aspects of drought events that lead to civil conflicts (Shen *et al.*, 2007: Alston and Kent, 2008; Von Uexkull, 2014). Hardship and the process of coping with prolonged drought in drier regions characterised by acute water shortage and limited resources to withstand such events, leads to

frustration, depression and unemployment, all of these issues breed conflicts in such communities (Shen *et al.*, 2007; Alston and Kent, 2008; Von Uexkull, 2014).

In recent years, northern Nigeria has experienced conflicts, especially due to the insurgence of Boko haram and clashes between farmers and herdsmen in the region. Problems of farmers and herdsmen can be due to the effects of desertification and drought in the north (Olagunju, 2015). Nigeria has a large pastoralist population and which depend on grazing land for survival (Daily Trust, 2018). The conflict between farmers and herdsmen is now considered as a threat to national security (Daily Trust, 2018). Many farmers have lost their lives due to unrest between them and herdsmen.

2.5. Effects of drought around the world

2.5.1. Effects of drought in Asia and Australia

Production of crops has declined in recent decades in many part of Asia with increasing water stress and temperature. Over 60 million people were affected by multiple droughts in Central and Southwest Asia in 1999-2000. The countries involved were Afghanistan, Uzbekistan, Pakistan, Iran and Turkmenistan (Mishra and Singh, 2010).

Drought has affected farmers' social life in semi-arid Bangladesh. Farmers there believed that climate change has increased drought frequency in the area (Habiba *et al*., 2012). However, climate change perception among local farmers in rural areas is influenced by their level of education, means of livelihood and locality (West *et al*., 2008).

Vietnam is among many countries with extensive records of climate issues, such as drought and floods. The country ranks 13th in terms of vulnerability to climate change impacts (Lohmann and Lechtenfeld, 2015). Rainfall received in Vietnam over the past few decades has been highly variable. Rural communities largely depend on rain-fed agriculture (Nguyen, 2011). Despite economic growth, many people live on <$1.25 per day, thus many household

incomes are below the poverty line (World Bank, 2012). Usually during droughts in Vietnam food prices increase and people downgrade the quality of their food (UNISDR, 2011). For example, the estimated cost of economic damage due to drought was $110 million, which is ~0.2% of GDP (UNISDR, 2011).

India is amongst the countries that mainly depend on rain-fed agriculture (Arlappa *et al*., 2011). Drought is a recurrent the probability and vulnerability to drought 35% and 30% respectively (Birthala *et al*., 2015). Despite the decline in India's agricultural activities, the sector contributed ~15% of GDP in 2013-2014. India has witnessed ~13 major droughts in the last five decades, most recently between 2001-2012 (Kumar *et al*., 2005; Birthala *et al*., 2015).

Drought is a problem that consistently affects farming in Iran (Dariush *et al*., 2010). Farmers' resources were depleted where water replenishment was problematic, causing human suffering and decreased crop production. Drought mitigation and coping strategies are limited, due to the Government's inability to reduce drought damage (Dariush *et al*., 2010).

Australia experienced the 'Millennium Drought' in the 2000s which lasted for almost a decade (Bond *et al*., 2008). The episode was one of the most severe droughts, where rivers recorded low flows, many <40% of usual discharge. The magnitude and severity of the drought also affected many fresh water ecosystems (Bond *et al*., 2008). Losses recorded were in billions of Australian dollars, where agriculture contributes ~5% of national GDP. There will probably be an increase in droughts in the future and the projections suggest that west and southern parts of the country will be most affected (Jenkins, 2012).

Chinese average economic losses due to drought from 1950-2002 were projected to reduce in the 2nd half of the 21st century (Jenkins, 2012). Drought cost $883 million from 1950-2002 and was estimated to cost $540 million from 2003-2050 in terms of projected economic

damage. China experienced severe droughts in 1997 and 1999-2002, which affected >40 million hectares (Zhang, 2003). There was pronounced drought in south-west China with decreased crop yields. The area is the most vulnerable to drought in the China with reduced wet season precipitation decreasing food yield (Lu *et al*., 2017).

2.5.2. Effects of drought in the USA and Canada

The USA has experienced droughts which have affected water levels in rivers and reservoirs (Cook *et al*., 2007). Affected States include Nevada, New Mexico, Utah and Wyoming. Lake Powell (Colorado) was affected by drought in 2004 and water levels fell (Cook *et al*., 2007). US drought history shows that drought has cost great loss and damage (Sahr, 2005). The aftermath of the 'Dust Bowl' drought of 1934-35 cost over $5 billion at the time, equivalent to $66 billion in 2002 (Sahr, 2005). Over $1 billion (equivalent to $13 billion in 2002) was spent on drought relief in the 1930s. There were drought episodes in 1980, 1988 and 2002, where the 2002 cost over $10 billion. The 1980 and 1988 episode cost ~$48.8 billion and $61.6 billion, respectively (Ross and Lott, 2003).

Projected drought economic damage for the USA will increase in the future by 87-105% in a worst case scenario. Estimated economic damage costs from 1950-2003 has increased from $5 billion to $35 billion, and are projected to increase from $35-105 billion between 2003-2050 (Jenkins, 2012).

Canada also experienced two droughts in 2001 and 2002, where crop production decreased by ~$930 million in 2001 and $2 billion in 2002, ~3 billion Canadian dollars in total. This was one of the most severe droughts Canada has experienced in recent years (Wheaton *et al*., 2008). Figure 2.2 show the severity of drought across the USA in July 1980, 1988 and 2002, respectively.

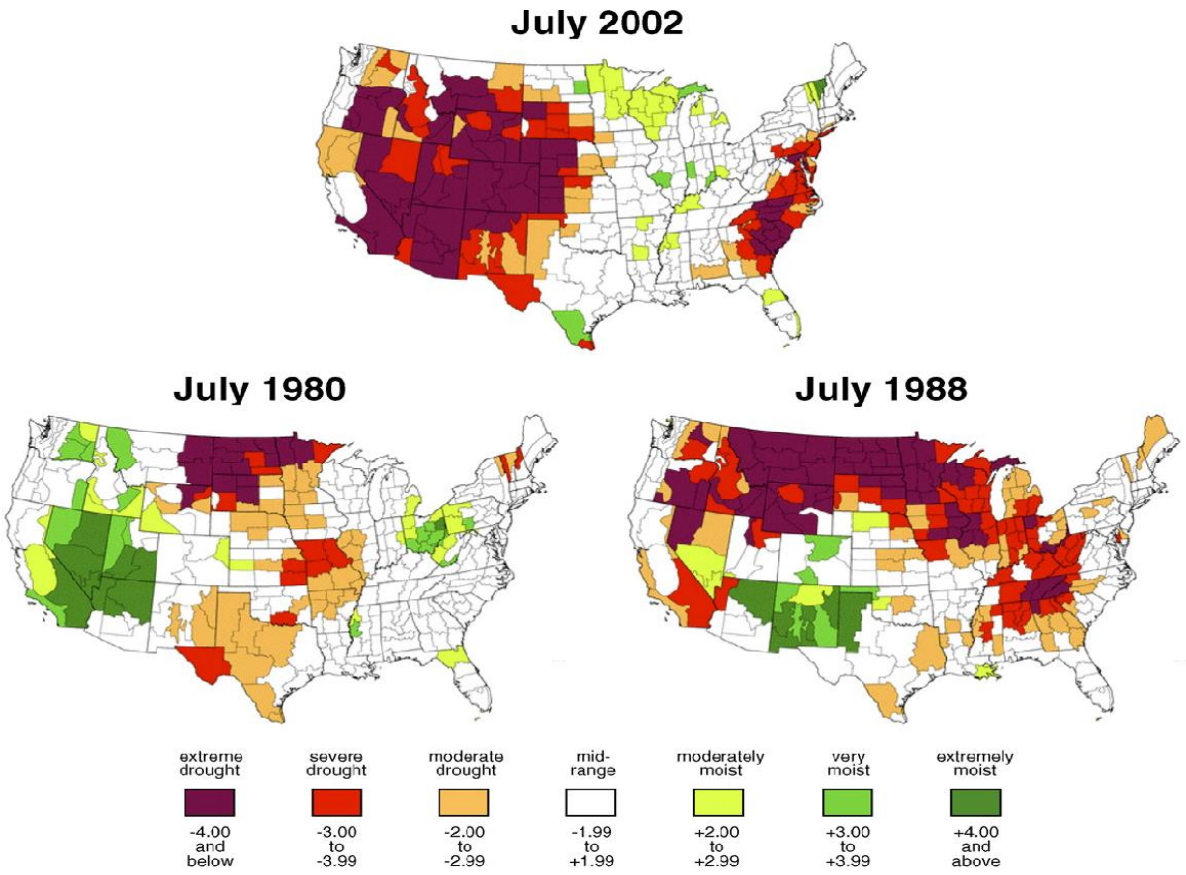

Figure 2.2: Map of the USA showing severity of drought in the 1980s and 2002 (Source: Cook *et al*., 2007).

2.5.3. Effects of drought in Europe

Drought has been recurrent in many parts of Europe in recent decades. Shortage of rainfall was a major threat in most of the continent over the past seven to eight decades (Cammalleri and Vogt, 2015). Due to climate change scenarios in Europe, drought is now frequent and widespread, especially in the Mediterranean region and the condition is worsening (EC, 2007; Cammalleri and Vogt, 2015). In the last three to four decades, Europe faced major droughts, especially in Northern and Western Europe in 1976. There were other events in 1989, 1991 and 2003 (Hisdal *et al*., 2001; Feyen and Dankers, 2009). In 2005, drought occurred in the Iberian Peninsula, which became the most severe in the region for over six decades, where it decreased EU cereal production by ~10% that year (UNEP, 2006). Over the past 30 years, drought has accounted for ~€100 billion of losses in Europe. Fleig *et al.* (2011) compared

drought severity and frequency in Denmark and the UK both countries experienced severe droughts in 1976 and 1996. The 1975/1976 drought is considered the most severe in recent decades (Fleig *et al*., 2011). In the summers of 1975 and 1976, the UK had low rainfall and experienced a severe drought, it was considered the worst since records started in 1766 (Marsh *et al*., 2007). Due to the 1975/76 drought ~£500 million worth of crops were lost (Marsh *et al.*, 2007). In 2015, drought affected much of Romania, the President of the Romanian Agricultural Producers Association stated that the event decreased crop production in the country, maize being the most affected. The estimated cost of losses was estimated at €2 billion (BR, 2015).

From 1991, the yearly cost of drought was on average ~€5.3 billion in Europe, but the economic damage of the 2003 episode cost ~€8.7 billion (European Communities, 2007). It is important to use historic extreme events to projects future events (Carter *et al*., 2007). Spinoni *et al.* (2015) projected that similar drought to the 2003 event in Europe will be more severe in the future, which will increase by ~100-fold in 40 years. Summers in some parts of the continent will also become warmer and drier, e.g. in Switzerland (Schär *et al*., 2004). Annual economic drought loss in Spain is projected to increase by 300%. Past annual drought events have cost ~$375 million from 1955-2002 and the loss is expected to increase to $1.1 billion from 2003-2050 (Jenkins, 2012). Feyen and Dankers (2009) used climate variables to assess drought severity and frequency, including temperature and precipitation, where they ran two seasons of a hydrological model of frost and frost-free periods of the year to predict the impact of climate change on streamflow in Europe. They concluded that by the end of the 21st century there will be low river flows and river volume. Future global warming models suggest that most of Europe will experience fewer frosts, which in turn will have negative impacts on water availability, thus leading to competition for limited resources (Christensen and Stott *et al*., 2004; Christensen, 2007).

2.5.4. Effects of drought in Africa

Africa is well known for desertification and drought (Agnew and Chappell, 1999). The continent has one of the harshest climate conditions in the world (Sivakumar and Wallace 1991). Africa's drylands are characterised by high temperatures, low humidity, low soil moisture and variable rainfall. There are three African regions where drought is a dominant feature, including the Kalahari-Namib region, Sudano-Sahelian region and Mediterranean Africa (UNEP, 1992). Drought has occurred in the Sub-Saharan Africa and has affected over 40 million in the 1980s. Due to the unpredictable climate variables in the Sahel, climatologists have failed to understand the extent of droughts. Many natural disasters affect Africa, but drought has the most negative impact in terms of the number of people affected (Vicente-Serrano *et al*., 2012). Drought has also caused epidemics and land degradation across Africa and is among the natural disasters that have caused highest mortality in Africa from 1974-2007 ~450,000 people died due to drought (Vicente-Serrano *et al*., 2012).

In 2011, severe drought struck Somalia, causing a large humanitarian crisis, which affected over 10 million people; 2 million among them were malnourished children, leaving 380,000 refugees in Kenya (Vicente-Serrano *et al*., 2012). In Africa, one-third of the continent is described as desertified and ~73% of agricultural lands are degraded (UNEP, 1992). If there are two to three seasons of drought across those regions, it will cause severe environmental stress (Lean, 1995). In Africa, drought and floods account for 80% of life loss and economic (Bhavnani *et al*., 2008). In 1990/1991 the GDP of Zimbabwe decreased by 11% due to drought related issues. In Kenya 1999/2001 drought cost an estimated $2.5 billion (Brown *et al*., 2011).

Drought problems in Africa have increased over the past decades, leading to decreased crop yields and impoverishment, unemployment and migration (Bhavnani *et al*., 2008; UN, 2008; Scheffran *et al*., 2012). The slow onset of the disaster causes most economic losses, because

it is not easy to predict where exactly the disaster will affect (Dai, 2011; Desanker *et al*., 2001; IPCC, 2007, 2014; Solh and Maarten, 2014). Numerous international organisations and programmes such as 'Sustainable Development Goals' (SDG), 'Eradicate Extreme Poverty and Hunger, European Commission Humanitarian Aid Program' (ECHO) and the 'Food and Agricultural Organisation of the United Nations' (FAO) have prioritised drought mitigation in Africa. In 2007 the EU allocated ~€53 million to mitigate the impacts of drought in Somalia, Uganda and Kenya (Bhavnani *et al*., 2008). Drought shock due to crop failure has increased in Sub Saharan Africa and has trapped farmers in acute poverty (Wossen *et al*., 2017). Farmers in the region sell their lands, assets and livestock as drought coping mechanisms.

In addition, the study showed that lack of formal insurance and a safety net in most Africa countries further increase vulnerability. Having such measures would reduce drought shock on farmers and increase their ability to cope. Farmers in Australia have such safety net through insurance from the government and other financial support (Stone, 2014). Improving the drought tolerance of crops can also serve as means of reducing drought risk to enhance future food security at the same time serving as insurance against crop failure (Wossen *et al*., 2017). Crop production during drought depends on its length and timing (Bodner *et al*., 2015). Drought decreases agricultural land productivity, which affects the supply of food to urban centres. Many people migrate to urban areas due to drought. Migration from rural to urban areas increases stress on water and other natural resources. In the past three decades, there have been efforts by governmental and non-governmental organisations, for example the 'Organisation of African Unity', to address the issues of drought and desertification in Africa (Msangi, 2004). The effort was introduced due to the 1968-1973 droughts, where the affected areas included the Eastern Sahel and Southern Africa. This was the first time in the Continent where ecological degradation received full attention from governments. Some

countries have faced rainfall shortages, including Zambia, Tanzania, Namibia, Kenya, Somalia, Zimbabwe and South Africa, which affected their agricultural production (Edossa *et al*., 2010). Rainfall received in these countries was mostly well below average, which led to starvation and human deaths. Droughts have damaged fragile ecosystems, increasing desertification in some parts of those countries (Msangi, 2004). This led to habitat fragmentation, destruction and loss which endangered the survival of many plant and animal species (Wood *et al*., 2000). In Africa, drought issues are usually regional rather than general disasters. Ethiopia has faced severe droughts, which occur once every 10-15 years (Abate, 1994). Figure 2.3 show the areas affected by drought in the Sahel region.

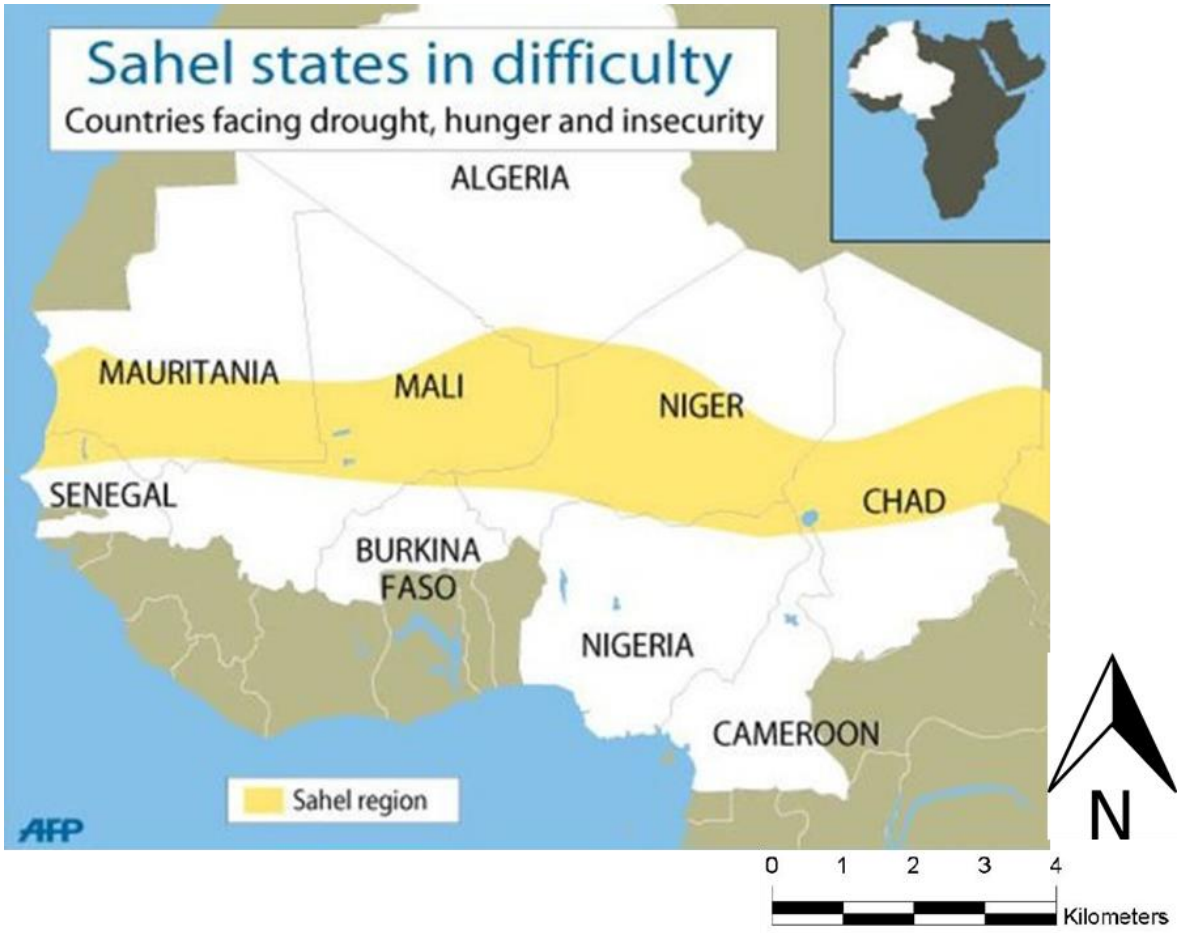

Figure 2.3: Areas affected by drought in the Sahel region (Source: UNHAR, 2012).

However, there is no specific pattern of drought recurrence in the country; this was noted due to dry years recorded every 5-6 years, based on rainfall analysis (Edossa *et al*., 2010). In Ethiopia, drought has damaged agricultural output. For instance droughts in Ethiopia in 1888/89 caused famine and ~90% animals died. In 1984, there was a severe drought which caused loss of livestock and crops. For example, Wollo Province had 61% and 94% loss, respectively (Little *et al*., 2006). In 1974 and 1984 over 325,000 people died in the Sahel due to drought mostly in Ethiopia (UN, 2008).

2.5.5. Environmental problems in Africa

Agnew and Warren (1996) reported the seriousness of environmental changes in the Sahel. Many people have suffered from drought events in the 1980s, which produced millions of environmental refugees. However, there are differences between environmental problems and changes. Environmental problems also have two major aspects; impacts of people upon the environment and impacts of environment on people. Any change in physical environmental conditions can cause environmental problems (Olsson, 1993; Batterbury and Warren, 2001). Most environmental problems in the Sahel are also considered cultural and economic, as they are triggered and created by poverty. Despite peoples' lifestyles adjustment during droughts, people cannot withstand severe events.

During severe events, without assistance from outside (relief), people do not consider environmental conservation important, due to their struggle for survival. Msangi (2004) argued that if droughts are properly managed, environmental degradation will certainly decrease. However, drought triggers environmental stress and resource degradation. This occurs when people are trying to overcome severe drought events, thus placing pressure and demands on resources, which in turn harms the natural environment (Ghai, 1992). Drylands occupy ~41% of the earth's surface and has a population of over 2 billion people (Pravalie, 2016).

2.5.5.1. Deforestation

Olagunju (2015) defined deforestation as the conversion of forest area into a non-forest land due to peoples' activities, expansion of agricultural land and development. Deforestation is one of the major causes of desertification in northern Nigeria, where vegetation is used for fuel-wood (Olagunju, 2015). The problems of deforestation include loss of biological productivity, economic and biodiversity loss mostly in arid, semi-arid zone (Reynolds, 2016). These are mainly caused by excessive fuel-wood gathering, poor irrigation practises and over-grazing. These processes are exacerbated by climate variability, such as drought can cause desertification. Desertification is caused by the complex interplay of land management and environment which leads to poor yield (Fullen and Mitchell, 1994). This can have both direct and indirect impacts on farmers and their livestock.

2.5.5.2. Land degradation and management

Land degradation in the Sahel is caused by climatic drought and anthropogenic factors (population growth, over-grazing and agricultural activities) (UNISDR, 2011). Most Africans are dependent on agriculture as their main source of income, ~80-90% of the people in the Continent, especially in the Sahel region are actively involved in agriculture.

Rural communities in the Sahel have been affected by recurrent severe droughts (Darkoh, 1998; Lei *et al.*, 2016). This has immensely affected socio-economic sustainability and led to high production costs, low productivity, crop damage and increased poverty. It is vital to explore possible means for effective solutions to reduce rural poverty under increasing climate change. Some countries have used land use management as adaptation strategies to mitigate the effects of drought on agriculture (UNISDR, 2011). During severe drought, inappropriate land use practises can increase drought impacts, whereas appropriate land use practises can improve productivity and reduce losses (Zhou *et al*., 2014). This was one of the reasons the Chinese government introduced afforestation and reforestation projects as

drought and climate change mitigation measures, Zhou *et al*. (2014) showed that this has yielded environmental benefits.

Carbon (C) retention in the soil plays a vital role in storing soil nutrients and afforestation is an effective means of C-sequestration (Witt *et al*., 2013; Segura *et al*., 2016). The strategy helps mitigate climate change impacts based on soil functions (Witt *et al*., 2013). This can also be achieved through plantations as they are land use systems that provide regulating, supporting, provisioning and protecting cultural ecosystems.

In Malaysia and South Africa, land use management is one of the important climate change adaptation strategies. Better-adapted crop varieties, altering planting dates and changing farming types have positive outcomes in terms of drought and climate change adaptation plans (Bryan *et al.*, 2009). However, these large scale strategies can have adverse impacts on socio-economic factors and cause insecurity to farmers' livelihoods in local areas. Exploring environmentally-friendly adaptation measures is important to reduce the effects of drought (Lei *et al.*, 2016).

Farmers in Kenya were trained to practice conservation agriculture, through crop rotation and reduce farm clearing after harvest (FAO, 2018). They were trained to allow weeds on their farms to reduce soil erosion. The FAO programme started in 2014 and by 2018, ~1,200 farmers depend on their farms for income. The farmers were trained to market their products to generate income. Macaulay (2014), concluded that land degradation in Nigeria can be reduced through irrigation, crop rotation and agroforestry.

2.6. Effects of drought in Nigeria

Drought has been a problem in West Africa for many decades, but did not receive adequate attention until the great Sahel droughts in the 1970s. Droughts persisted for ~5-6 years in the region where it affected millions of people, caused famine in the region and have produced

millions of environmental refugees (Mortimore, 1989). Countries in the region including Senegal, Mauritania, Mali and the Niger Republic, have received much attention of international media and support. The number of people affected in northern Nigeria is more than those affected in the aforementioned countries combined (Mortimore, 1989). Lack of international media's attention was due to Nigeria's economic stability, considering it oil wealth. This has left many Nigerians from the north in acute poverty and starvation. The northern states severely affected by the 1970s droughts are those adjacent to the Niger Republic. This might be due to their aridity and ecological zone of the states which is vulnerable to drought. Recurrent drought in the 1970s, especially the episodes of 1971, 1972 and 1973, has affected agricultural production in Nigeria (Mortimore, 1989).

Agriculture contributes ~18.4% of national GDP, but after the 1970s events production declined, thus contributing only 7.3% to GDP. Irrigation is important, as it will boost the contribution of agriculture to national GDP (Abubakar and Yamusa, 2013). The study of Olagunju (2015) examined both desertification and drought in northern Nigeria. It reported that threats posed by drought and desertification are due to growing poor population in the region, which causes mass migration, increased environmental refugees and exacerbated conflicts. Drought is mostly severe in the northern Nigeria (north-west and north-east) due to its unstable rainfall pattern and short rainy season (Adefolalu, 1986). Causes of drought in the region are related to reduced rainfall, cloud cover and high evaporation rates, which are triggered by human activities such as deforestation, bush burning, overgrazing marginal land and poor cropping (Abubakar and Yamusa, 2013). Droughts in northern Nigeria have caused starvation, famine, declined social and economic activities and dwindling freshwater supply in the region (Mortimore, 1989; Oladipo, 1993).

Drought in northern Nigeria has caused critical biodiversity habitat loss, migration, decreased rainfall, increased deforestation, poor harvest, death of lives, conflict due to grazing land and starvation (Nwokocha, 2016). All these studies have identified similar socio-economic and environmental problems of drought in northern Nigeria. Thus, it is important to investigate and develop comprehensive drought mitigation measures.

2.6.1. Impacts of the 2009 drought in Yobe State

In 2009, Yobe State and neighbouring states experienced a severe drought that affected many livestock and crops. The episode led to the mortality of farm animals and severe crop damage, thus reducing total food production (ICDA, 2010). Water bodies were also at their lowest during the episode, damaging socio-economic activities within the State. This affected prices of food and livestock in markets. Yobe State has the largest livestock market in Nigeria. Common crops harvested in the State include beans, maize, guinea corn and pea nuts. Livestock reared in Yobe State include sheep, goat and cattle these farm animals were also affected the drought (ICDA, 2010). Table 2.2 reports the due to the 2009 drought in Yobe State.

Table 2.2: List of product losses from the 2009 drought

S/no.	PRODUCTS LOST	ESTIMATED COST N (billion)	ESTIMATED COSTS (UK £, million)
1	Crops	1.26	4.10
2	Livestock	1.50	6.00
3	Fodder	5.00	20.0
4	Fisheries	1.52	6.20
5	Water resources	1.00	4.00
6	Environment	2.00	8.00
	TOTAL	12.28	48.3

(Source: ICDA, 2010).

The harvest loss data were collected immediately after the 2009 drought in markets by calculating the number of tonnes produced the previous year 2008 and 2009 to assess harvest losses in different Local Government Area (LGAs) of the State (ICDA, 2010). Table 2.3

reports the harvest losses from the two harvest seasons. The assessment was conducted to ascertain the economic losses caused by the drought (ICDA, 2010).

Table 2.3: List of LGAs in Yobe State and estimated lost crop production due to the 2009 drought

S/no.	LGAs	Production (tonnes)		Losses	
		2008	2009	Differentials (t)	% loss
1	Bade	301.4	198.6	188.1	60.4
2	Bursari	311.3	123.2	103.0	34.1
3	Damaturu	672.5	386.4	243.6	28.9
4	Fika	698.4	455.2	243.2	34.8
5	Fune	475.0	233.0	242.0	50.9
6	Geidam	766.5	521.2	245.3	32.0
7	Gujba	825.2	522.9	302.3	45.5
8	Gulani	372.3	177.7	194.6	52.2
9	Jakusko	337.4	178.8	158.6	47.0
10	Karasuwa	475.5	305.3	170.2	35.7
11	Nangere	326.4	167.8	158.6	48.5
12	Nguru	212.8	104.3	108.5	50.9
13	Machina	841.1	589.5	243.6	28.9
14	Potiskum	841.1	597.5	243.6	28.9
15	Tarmuwa	452.0	265.0	187.0	41.3
16	Yunusari	141.7	75.70	66.00	46.5
17	Yusufari	193.3	89.60	103.7	53.6
	Total	7680.1	45389	3141.2	40.90

(Source: ICDA, 2010).

2.6.2. Hydrogeology of Yobe State and potential for irrigation

Yobe State is part of the Chad formation, with fresh-water sedimentary sequences, which contains much ground-water (Musa, 2011). The aquifer was further divided into three horizons, (upper, middle and lower aquifer). The upper aquifer comprises of mainly fine sand, clay and silts. Ground-water is present in the upper aquifer of the Chad formation and is recharged by seasonal rainfall (Dawoud and AbdelRaouf, 2002; Adeaga, 2011). The water table rises during the rainy season and drops in the dry season. Hand-dug wells and boreholes are drilled between 10-40 m, depending on the area. Boreholes and wells drilled during dry seasons tend to be deeper than those drilled during the rainy season. Irrigation activities

mostly use dams, boreholes and hand-dug wells (Musa, 2011). This suggests that irrigation practises have much potential in Yobe State.

Irrigation is one of the effective measures to cope with drought and mitigate it impacts (Abubakar and Yamusa, 2013). However, considering the demand of water for irrigation, it difficult in some region (Schaible and Aillery, 2017). Large scale irrigation in drought prone areas has not achieved the expected result under the World Bank irrigation project around Lake Chad in northern Nigeria (ODI, 1987). Wheat was irrigated during the Project, after the harvest it costs eight times more than imported wheat due to the management of the project. The study suggested that locally managed irrigation projects would yield more, due to farmers' commitment and lack of bureaucratic processes. Famers have a stake in all projects designed during drought mitigation in order to help them maintain it properly (ODI, 1987). The scale at which irrigation should be conducted and managed should be monitored and properly planned.

Problems of soil salinity during irrigated agriculture are common in places with low rainfall and high evaporation (Rietz and Haynes, 2003). Improper irrigation practise and drainage management cause soil salinity, through capillary movement of dissolved ground-water salt to reaching the topsoil. Most irrigation in arid zones have challenges (Lambert and Shiati, 2002). Recently, there has been increase in irrigation activities in semi-arid and arid regions, due to steady decrease of fresh water (Mehmet and Hakan, 2016).

2.7. Identifying stakeholder's role in adaptation strategies

There are three main functions of governments and the private sector in climate change adaptation. The roles can be identified as: (i) stabilising the economy, (ii) facilitating efficient allocation of goods and services (for example, stable environment, education, and security) and (iii) adequate distribution of income (Aakre *et al.*, 2010). The role of government is

important, because it ensures that all policies and planned guidelines are developed and followed. However, government adaptation policy should at least include these four objectives: (i) increase robustness of infrastructure, (ii) increase flexibility and adaptability of vulnerable managed system, (iii) reverse trends that increase vulnerability and (iv) improve awareness and preparedness (Klein and Tol, 1997). Berkhout (2005) argued that it is necessary for governments to be involved in influencing climate change for mitigation action to protect public goods. The study also proposed another set of seven objectives for public climate change adaptation and many match those proposed by Klein and Tol (1997). These include: informing the potentially vulnerable, to assist in the provision of disaster relief, provide incentives to enable adaptation, mainstream climate-proofing public policy, plan and regulate long-term infrastructural assets to reduce future vulnerabilities, regulate adaptation and compensation for the unequal distribution of climate impacts. Governments should play vital roles in the following objectives:

Information, knowledge and learning: Sponsoring climate science and also providing necessary tools to understand climate scenarios.

Early-warning and disaster relief: Preparing organisations and resources to inform people and communities on weather-related events and how to cope with their consequences

Regulating adaptation spill-overs: Governments should identify and consider vulnerable communities and individuals that take most climate change risk (Aakre *et al.*, 2010).

2.8. Challenges of drought proactive preparedness

Preparedness is the process of pre-disaster readiness to improve operational and institutional capacities to respond to drought (Eludiyon *et al*., 2017). Preparedness is a vital component of disaster management processes and its improvement is crucial (Wilhite, 2016). Most drought impacts vary in specifics and depend on systems (for example, community and agricultural sector susceptibility to damage). This influences the capability of mitigation and preparedness

for responses to recover from droughts. Increased adaptive capacity means decreased vulnerability and *vice-versa* (Smit and Pilifosova, 2003). Capability of system's adaptability can be influenced by resources and livelihood choices. This shows that every system experiences drought differently and has different adaptation strategies.

Drought preparedness methods, capacity and strategy differ for every system (Rusca *et al.,* 2012; Hill *et al.,* 2014). Traditional crisis management approaches have been challenged by extreme droughts, and deep uncertainty of climate and water resources in the future, which calls for adoption of proactive management approaches. Proactive approaches need to be emphasised for better mitigation of extreme drought, where this should include all stakeholders in the planning process (HMDP, 2013). This will possibly ensure best solutions are accepted by all stakeholders. Proactive drought preparedness is challenging for three reasons:

- It is difficult for all stakeholders to take into account all factors that influence drought preparedness.
- It is difficult to plan for severe drought based on victims' experience and history records.
- Droughts occur sporadically, thus management is difficult due to time and financial constraints (Rusca *et al.,* 2012).

New coping strategies need adequate Early Warning Systems (EWS), which can be difficult due to drought variability, pace and magnitude of changes in specific areas. Constraints in preparedness include the lack of methodologies for policy-makers and planners for proper guidance of appropriate planning processes (Wilhite *et al.,* 2000). Other studies show that drought preparedness include water supply, expansion of irrigation facilities, public awareness and education (UNISDR, 2009). Wilhite *et al*. (2000) highlighted different drought preparedness measures which include:

- Enhancing understanding of seasonal forecasts and decision support tool to improve the resilience of vulnerable groups and sectors to drought.
- Identifying incentives that could be provided to vulnerable groups to adopt proactive measures
- Identifying and communicating examples of how interagency and ministerial co-ordination can enhance drought monitoring, response and planning.
- Collect local and traditional knowledge and incorporate it into decision-making processes

In developing countries many preparedness measures have not been successfully reflected in practise. This causes ineffective and inaccurate drought monitoring and warning systems (Wilhite *et al*., 2000).

2.9. Drought mitigation measures in different countries around the world

Drought management plans of several countries and regions are presented below, in order to ascertain how they mitigate and manage drought impacts. Some of the countries include Spain, Central Eastern Europe, Mexico, Australia and South Africa. These countries were reviewed because their mitigation and management plans emphasised proactive measures and they engaged stakeholders at different levels.

2.9.1. Central East Europe (CEE) drought mitigation plan

Past decades have indicated frequent and increased severe drought in Central and Eastern Europe (CEE). Countries in the region include Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Hungary, Romania and Bulgaria. All the proposed criteria are to improve drought management tools in the region (Bokal *et al.,* 2014).

Vulnerability of the region to drought prompted governments, public and utility agencies to consider numerous socio-economic problems in CEE and the need for drought mitigation measures (Andreu and Solera, 2006). The region initiated the 'Integrated Drought Management Programme' (IDMP), which operates within the joint framework of the World Meteorological Organisation (WMO), Global Water Partnership (GWP) and Integrated Drought Management Programme (Estrela *et al.,* 2006). One important scope of the joint framework is to support stakeholders with proper guidance and management policy at all levels, and with globally co-ordinated generation of scientific information and sharing of best practices with stakeholders (Bokal *et al.,* 2014). The programme focuses on four key issues:

- Changing drought management from reactive to proactive programmes by using mitigation, vulnerability reduction and preparedness.
- Integrating planning systems and decision-making processes at all levels from national, regional to community level and incorporate different sectors and disciplines.
- Promoting knowledge-sharing among stakeholders within the framework, based on experience.
- Promoting capacity building of all stakeholders at all levels.

The WMO/GWP Framework in the CEE region was proposed to be implemented in two phrases. Based on the first phrase, four categories of national and regional initiatives were proposed:

- Introducing drought preparedness measures (investment and non-investment measures and drought insurance systems).
- Improving drought early warning and monitoring systems.
- Introducing capacity building programme for water managers and farmers.

- Developing a database to document good practises in the application of integrated drought management.

2.9.2. Drought management plans in Spain

Spain is characterised by water scarcity and frequent and often severe drought (Andreu and Solera, 2006; Andreu *et al.,* 2013). Spain has gained experience through implementation of policies, applied tools and technologies for drought management plans (Estela and Vargas, 2012). The application of tools allows and stakeholders to predict and manage droughts through agreed criteria, to mitigate long-term environmental and socio-economic effects. The Spanish Drought Management Plan has shifted from crisis to the planned risk management approach (Ministerio de Medio Ambiente, 2005). In 2005, the Ministry of Environment compiled data with the aim of reviewing climate change impacts to prepare for future events and update adaptation initiatives. The assessment report shows that there will be: (i) general decrease in water sources, (ii) 50% reduction in water resources in semi-arid and arid regions, (iii) seasonal rainfall patterns will affect temperature and water resources, (iv) there is a need for improved monitoring of hydrological networks, to consider how climate change effects water policies and regulations (Ministerio de Medio Ambiente, 2005).

2.9.3. Mexican National Drought Policy (PRONACOSE)

In Mexico, ~66% of the land area is classified semi-arid, it also has a total population of 105 million and drought vulnerability is increasing. Mexico has been using traditional methods to minimise the impact of droughts (Federman *et al.,* 2014). The Government is trying to shift from traditional to more preventive action measures to curtail these impacts. The severity of the 2011-2012 droughts prompted the National Water Commission (Conagua) to initiate a framework to minimise drought effects through non-traditional methods. Under the

Framework, 26 basin councils were given guidelines and independent plans by Conagua. The Guidelines provide operational directions drought management plans (Federman *et al.*, 2014).

The Federal Government of Mexico supported the initiative by developing a National Drought Program (NDP), (PRONACOSE) to ensure full participation of governments at all levels in complete implementation of the Framework. The PRONACOSE approach comprises of both prevention and mitigation by estimation of important resources. It has defined actions and structure for stakeholders to reduce the effects of drought on people, goods, infrastructure and the environment (HMNDP, 2013). PRONACOSE also encourages forecasting for drought, early warning and data dissemination. This includes timely collection and analysis of hydrometric and climatic data and information on reservoirs; drought locations and intensities. There is promotion and co-ordination by Federal, State and municipal governments for joint programmes on water usage. This includes training on water demand reduction action, understanding monitoring information and efficient water usage. The drought policy supports all basin councils in designing their drought plans, based on water utilities, irrigation programmes and water sources. PRONACOSE is designed for five years (2013-2018) and will be subject to review (Federman *et al.*, 2014).

The basis of the National Drought Policy is also to deal with how Conagua will announce the onset and end of drought and recommend which actions are to be developed and adopted by the Basin Councils and major water users. This is to ensure that Basin Councils can effectively deal with drought and be able to evaluate their performance after each drought. It also deals with all planning stages before, during and after drought, including quantification of resources. In 2013, Basin Councils were directed to develop their five-year drought plans considering their drought features, vulnerability, triggers, actions and how they will implement and evaluate performance (Federman *et al.*, 2014). Basin Councils were also tasked with creating awareness among local water stakeholders on drought, involve experts

and strengthen research. This is to acquire up-to-date information on drought features and triggers in every Basin Council.

2.9.4. Australia's drought policy

Australia is noted for its extreme rainfall variability (Love, 2005). The Government regards drought as similar to other natural disasters, such as cyclones and floods. Droughts receive similar responses as other natural disasters, in terms of interventions and relief arrangements (Stone, 2014). Four decades of climate science had contributed to improved understanding of climatic variability in Australia and has also provided highly advanced forecasting research (Stone, 2014). However, there are major shortcomings in most drought monitoring systems (Vicente-Serrano *et al*., 2012). This is important in checking the usefulness of monitoring systems. Monitoring drought conditions in different places require environmental, socio-economic and hydrological detail (Burke and Brown, 2007).

Some States in Australia have introduced policies that are aimed at helping farmers and drought victims manage their risks, especially financial risks. For example:

- Farm management deposit: to support farmers in managing their financial variability that arises due to climate events or market fluctuations and tax relief to help minimise losses.
- Training and farm planning. For example, deliver workshops on farm management. New South Wales and Queensland have introduced climate and weather workshops.
- Drought preparedness programmes to help with actions before droughts and initiation of research into forecasting to support planning and the preparedness process.

Most of these strategies are used by farm businesses to deal with the volatile operating environment which is usually achieved with little Government support (O'Meagher *et al.,*

2000). There are possible ways to improve farmers' self-reliance. For example, in the 1990 severe and prolonged drought, ~70% of farmers received no drought relief or support. Similar droughts recurred in 2002-03 and 2007-08. Several strategies have been implemented for farmers to use at their discretion (White *et al.*, 2005) (Table 2.4).

Table 2.4: Impacts of drought on farms in Australia

S/No	Industry	Some impacts of drought	Farm level management strategies
1	Broad acre grazing	Reduced pasture growth; consequent reduced meat and wool production. Reduced land carrying capacity.	Supplementary feeding. Containment paddocks.
2	Dryland cropping	Quantity and timing of rain prior to and during the growing season.	Variable use of inputs as season evolves. Diversification of the farm business. Change crop varieties and/or types, adjust planting dates, change fertiliser regimes.
3	Irrigated Cropping	Water allocation reduced or nil allocation, depending on drought severity.	Choose not to plant on temporary switch to dryland production. Diversification of farm businesses.
4	Horticulture	Reduced to low water allocation	Allow some plants to die Pruning to minimise water use
5	Dairy farming	Reduced pasture growth and heat stress	Increased supplementary feeding. Animal shading sprinklers.

(Source: Stone, 2014).

Australia's drought management strategy is mainly based on a self-reliant approach for primary producers in their farming operations and drought preparedness (Love, 2005). Drought relief and subsidies have been provided for decades as natural disaster relief, where expenditure for drought dominated the relief arrangement (Love, 2005). In 1989, it was announced that drought relief will be removed from the relief arrangement. This was due to misuse of the drought relief intervention funds by some State governments. Australian National Drought Policy was implemented as a national policy and was intended to have uniform national approaches. However, State governments have adopted different implementation strategies (Love, 2005).

2.9.5. Drought management in South Africa

Drought policy in South Africa had focused on supporting stock farmers; it was reviewed and amended to emphasise commercial output of agricultural production (O'Meagher *et al.*, 1998). There is increased overstocking during prolonged droughts. This served as part of the philosophical base to review drought policy (O'Meagher *et al.*, 1998). Reviewed policy added drought relief assistance, aimed at agricultural resource preservation. The new policy also introduced some criteria. These include: (i) application for disaster drought declaration, (ii) distinct drought declaration assessment criteria and (iii) eligibility criteria. The introduced criteria for disaster declaration required District Drought Committees (DDC) and the National Drought Committee (NDC) to be established and appointed by the Minister of Agriculture, where farmers lodge submissions through the Committees (O'Meagher *et al.*, 1998). The Committees also make their recommendations to the Minister of Agriculture. For farmers to qualify for drought assistance, they must reduce the size of their grazing area and its usual carry capacity during droughts (Smith, 1993). These are some criteria farmers have to meet to secure bank loans and subsidies. The drought policy and disaster aid scheme lacked scientific assessment criteria, which has insufficient protection for other natural resources after drought (O'Meagher *et al.*, 1998).

2.10. Importance of Early Warning Systems in decision making

An Early Warning System (EWS) is system of data collection to monitor both natural and human disaster, so as to provide timely information of possible threats and their mitigation (Buchanan-Smith, 2000). The success of the system depends on many factors, especially the decision-making process (NDPC, 2000). Most drought prone and food-insecure countries tend to depend more on government donation during the planning process for possible droughts. However, others sectors also need to participate in the process, for example commercial traders, farmers and NGOs. Using EWS alone during planning is ineffective and

insufficient. The EWS should be able to trigger timely intervention before the crisis occurs, to protect threatened lives and livelihoods (Davies *et al.,* 1991). Furthermore, the system should be able to protect future consumption capacity and maintain current status. However, both NGOs and government agencies must collaborate in joint assessments in order to minimise mistrust and harmonise responses to impending crises (Buchanan-Smith, 2000; NDPC, 2000).

An early warning system should comprise of the following:

- Meteorological information.
- Agricultural information.
- Price trends of food and feed.
- Availability of drinking water.
- Household vulnerability.

EWS provide information of drought onset, continuation and termination to decision-makers at all levels. EWS should not be a process of data collection and analysis as an end in itself, but be regarded as a process within drought mitigation strategies (Monnik, 2000). Drought EWS should also focus on the vulnerability of farmers and poor rural communities. The vulnerability profile of a region or area provides decision-makers with maximum information and direction of effective responses to a disaster (Monnik, 2000). However, the physical aspects of EWS comprise of severity, duration, time and spatial extent of drought data.

2.10.1. Factors affecting Early Warning Information

There are several factors that affect responses to Early Warning Systems. These include:

Ownership of Early Warning: Ownership of EW information is paramount to its effective use. The trustworthiness of the information provider is crucial (FAO and NDMC, 2008). NGOs and other donors do not use EW information provided by some government agencies,

especially when there are strained and have suspicious relationships. For example, in the 1980s NGOs in Ethiopia did not use EW information provided by the Government. Rather, they created a parallel EWS or used information provided by the UN Food and Agriculture Organisation (FAO) and World Food Programme (WFP) (Davies *et al.*, 1991).

Consistency and accuracy of Early Warning System information: There has been substantial investment in drought EWS in recent decades, which has improved EW accuracy (Buchanan-Smith, 2000). In drought prone regions, agencies often have their own EWS for an area and NGOs operate a different EWS, but usually at a smaller scale. The USA has a popular famine EWS which was developed and used by the US Agency for International Development (USAID). However, this EWS needs checking and scrutiny in other parts of the world, due to the situation and scale of the disaster (Buchanan-Smith, 2000). Lack of consistent and clear EW information affects responses. Agencies and departments responsible for the data gathering for decision-makers should assess every impending event differently, as each episode varies in intensity, magnitude and pace. Reliability of the information and responses can be evaluated after events (Thomson *et al.*, 1998).

Early Warning Information interpretation: The predominant response to drought is food aid. Experts show that most challenges at times are translating EW information into adequate food aid requirements (Thomson *et al.*, 1998). Usually, traditional methods, such as food balance sheets are used. Recently other new methods, such as the Food Economy Approach were introduced, which in the process of data collection considers factors such as vulnerability and food access (Wilhite *et al.*, 2005). Using different indicators for EW assessment gives decision-makers accurate information for timely responses and the resources required. Drought EW in Kenya considers indicators such as environment, economy and human welfare. Subsequently, it delivers messages to decision-makers through the use of a predefined warning sequence that consists of stages which start from ‘normal’ to

'alert' to 'alarm' and finally to 'emergency'. This defines the process of response and scale of the impending event and adverse appropriate responses (Buchanan-Smith, 2000).

2.10.2. Methods of improving Early Warning Systems in decision making

It is important that EWS information be accessible, clear and easily understood by decision makers. This appears simple, but is difficult to achieve in practise, especially, if there is conflict in the EWS methodologies and information is incomplete. EW information is mostly used when the sources are trusted, but it is likely to be trusted if decision-makers are involved in the process (Haji-Kazemi *et al.*, 2013). Sometimes it is important to delay EWS to evaluate its reliability. If crucial information is missing in drought prone regions, it is vital to have contingency plans for emergencies (Buchanan-Smith, 2000). Most drought mitigation policies Nigeria are designed at governmental level without proper public consultation (Oladipo, 1993). This is one of the reasons most government strategies are not properly implemented. Thus, this research produced a framework suitable for both government and local communities affected by drought. During the framework evaluation, farmers were enthusiastic zeal in participating in the process of drought mitigation, as it is beneficial to them.

2.10.3. Importance of indigenous knowledge in drought mitigation

Eludiyon *et al*. (2017) defined indigenous knowledge as a local skill unique to a given place and culture. An important characteristic of mitigation practices among rural farmers is local or indigenous knowledge (Nyong *et al*., 2007). It is important to integrate this knowledge into drought mitigation practises in places characterised by recurrent drought such as the Sahel which may also provide guide cause for mitigation of future droughts.

2.11. Improving drought monitoring and management

Monitoring, planning and preparedness are important ways to mitigate these impacts (Wilhite and Buchanan-Smith, 2005). Financial cost of relief and crisis management are difficult to

maintain, as drought severity, frequency and intensity are increasing (DNN, 1998). Technology incorporates communication skills, computer networks, Geographic Information Systems (GIS) and remote sensing. All these have improved our capacity to measure characteristics and weather-related disaster indicators for orientation and planning. Ground observations of precipitation and other meteorological observations have improved the ability for potential analysis of past, present and future weather conditions. Automated Weather Data Networks (AWDN) are an accurate method of weather observation and data collection and are mostly used to gather ground weather information in remote areas. The use of ocean surface observation is another means of monitoring drought. Routine use of meteorological satellite provides timely and increasingly accurate data, which covers more spatial terrestrial information. Data collected are transformed from observed radiance into environmental variables, such as temperature, cloud, snow cover, sea ice and vegetation (Brusberga and Shively, 2015). Using these techniques and other enhanced models provided by current technology can help in monitoring and planning drought mitigation and risk management (Wilhite and Buchanan-Smith, 2005). FGN (2005), stated that drought monitoring in Nigeria will be improved to reduce its negative impacts by implementing Early Warning System.

2.11.1. The drought monitoring system of the USA

Shifting from traditional crisis management to risk management requires proper drought monitoring systems. This should be part of a comprehensive approach to assessment and management (Wilhite *et al.,* 2000). The National Drought Mitigation Center (NDMC) gathers information and data for the development of reliable and timely water supply assessments about every region. It provides the current weather assessment and water supply conditions on the web site (NDMC, 2016). There is also a ‘drought watch section’ on the web site, which gives information models, such as Standardized Precipitation Index (SPI). It also provides data on snowpack, soil moisture, crop condition, streamflow, ground water level and

fire danger (Wilhite *et al.*, 2005). The web site provides useful information and data on drought for planning and management. To improve the robustness, reliability and scope, the Center had collaborated with other government agencies, such as the US Department of Agriculture with the Joint Agricultural Weather Facility (USDA/JAWF), and National Oceanic and Atmospheric Administration's Climate Prediction Center (NOAA/CPC) to establish a drought monitoring facility (NCEI, 2013; NDMC, 2016). The collaboration has produced positive outcomes. There was a significant advance in information availability and frequent usage by decision-makers. It has also successfully engaged local and regional experts on drought reviews. Drought monitoring maps were also developed and are widely used for their operation (Figure 2.4).

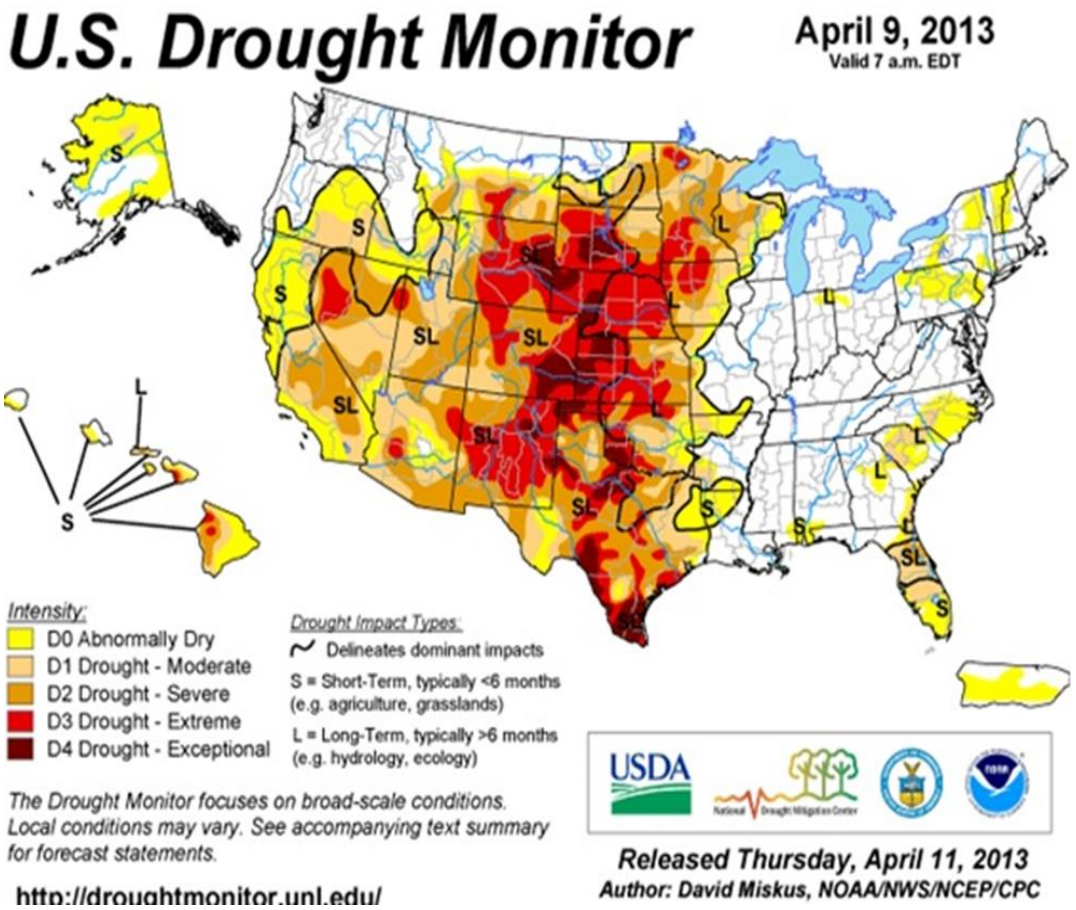

Figure 2.4: Drought Monitor Map (Source: National Center for Environmental Information, (NCEI, 2013).

Monitoring maps of drought severity describe drought impacts, future threats and predicted methods of improvement. In the Drought Monitor, droughts are categorised into different scales from 0-4 (D0-D4), where D0 indicates abnormally dry areas and D4 indicates regions with exceptional droughts. The map shows D0 as dry area but not in drought but headed towards drought, whereas D2 is severe drought and D4 exceptional drought (NCEI, 2013).

2.12. Need for national drought policy

There is a need to establish a national drought policy in order to serve as guidelines to oversee drought management in countries affected by drought (Wilhite, 2016). Oladipo (1993) proposed a national drought policy to help mitigate drought as the haphazard approaches in the 1970s and 1980s did not yield a productive outcomes. If proper and comprehensive drought mitigation policy and measures are not in place, the impacts of drought will affect more people.

Proactive or risk management approaches should be given more emphasis, as the crisis management approach has yielded poor results. This should be guided by application of adequate preparedness and mitigation measures (HMNDP, 2013). Complexity of drought impact is associated with several climatic and socio-economic factors, as they define the level of societal resilience (Wilhite, 2016). Adopting a drought policy helps to establish guidelines and clear principles of drought management, by identifying preparedness and mitigation strategies (HMNDP, 2013). There are several challenges associated with drought mitigation in developing countries, these include financial and technological constraints, human resources, access to new varieties of crops, water resource management, poor information dissemination and high illiteracy (Solomon *et al*., 2007).

All policies should give more emphasis to reducing risk through establishing adequate awareness and understanding causes of drought vulnerability. They should include methods

of better understanding proactive approaches, which can improve societal resilience. Shifts from traditional methods of crisis management to risk management can be achieved by improving seasonal weather forecasts, integrated monitoring and early warning systems. Drought experts suggest that preparedness should be planned at all levels, as part of the mitigation process, which creates a 'safety net' for relief and emergency response (HMNDP, 2013). Co-ordination between government and stakeholders should be maintained whilst developing a drought policy. The issue of water resource management needs a multidisciplinary approach, involving policy experts, scientists and engineers. Building institutional capacity is one major strategy to mitigate the effects of increased droughts (HMNDP, 2013). Drought mitigation requires the use of all components of the disaster management cycle (risk and crisis management), rather than using only crisis management. The importance of adopting this new risk management approach is to improve and develop preparedness, mitigation and early warning to reduce cost to governments and other donors' after events (Wilhite, 2016). Figure 2.5 illustrates the processes of both proactive and reactive measures of drought mitigation.

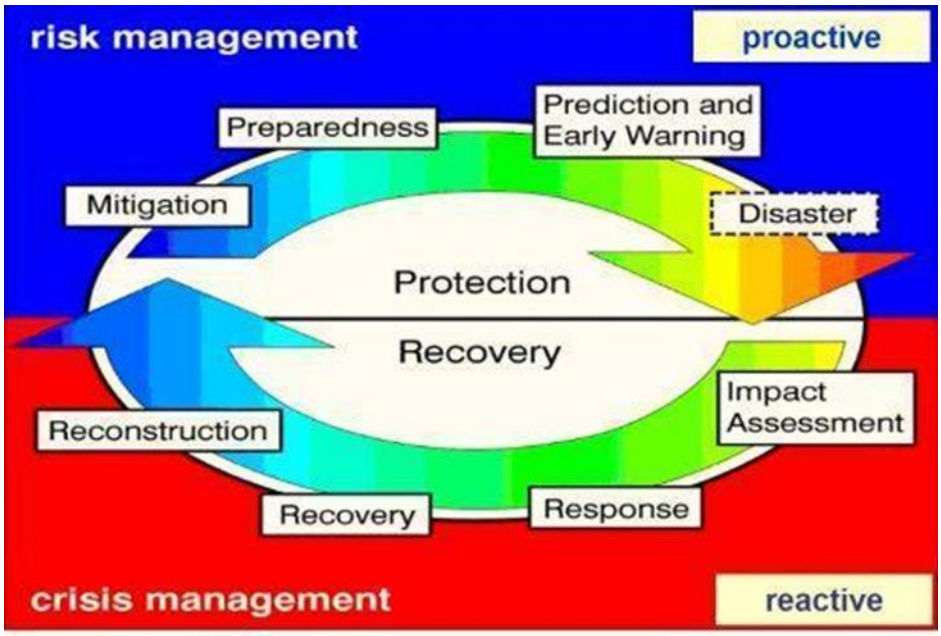

Figure 2.5: Disaster management cycle (Source: Wilhite, 2016).

The approach addresses symptoms of drought before manifestation and identifies possible means to curtail or mitigate effects. However, it is difficult to shift from traditional crisis management to proactive measures, usually because drought develops slowly. Implementing drought policy needs proper consideration, planning and preparation techniques to ensure most/all aspects and variables are incorporated. For example, defining objectives and methods to achieve the desired goal during the preparation stage make policies more robust (Wilhite, 2016).

2.12.1. General strategies for implementing National Drought Policy

Numerous countries are faced with challenges in developing national drought risk management policies (Gbahabo, 2011). Strong political will at the highest levels of government are required and stakeholders should be involved in the process (HMNDP, 2013; Wilhite, 2016). The risk management based policy provides a framework for a paradigm shift from traditional to proactive approaches. One of the most important steps is vulnerability mitigation. The policy should be developed and implemented across all levels of government, and should include the mitigation plan and preparedness strategies (HMNDP, 2013; Wilhite, 2016). Wilhite (2016) and HMNDP (2013) provided a guidance template for nations to follow in adopting a national drought policy; the 10 recommended steps are:

Step 1: A national drought management commission should be established.

Step 2: Clear goals and risk assessment should be defined.

Step 3: Stakeholders at all levels should be included to resolve conflicts between water users.

Step 4: Inventories should be taken to identify groups at risk of drought.

The first four steps should be considered based on local stakeholders' knowledge of the area.

Step 5: Preparation of a national drought-management policy and preparedness plans. Drought mitigation plans are essential part of national policy. It is recommended that the preparation should be in two forms; the traditional reactive strategy that deals with intervention after events and a proactive strategy. Usually NGOs and governmental organisations will collect their data to address impacts on sectors. Poor co-ordination and misinformation will affect the process and the desired targeted group might not receive appropriate assistance.

The second form is the proactive strategy, where preparedness and mitigation planning are essential. Vulnerabilities are identified at the planning stage using analysis of recent droughts. All provinces or states can collect and analyse their drought related-data. They must create criteria for declaring drought, provide organisational structures and define duties and responsibilities of agencies during, before and after drought. Reliable data on short-long term water availability is crucial during both wet and dry seasons. A monitoring committee should regulate and review findings on drought. A risk assessment committee on mitigation and response committees can also be formed (HMNDP, 2013; Wilhite, 2016).

Step 6: Timely research should be conducted to fill institutional gaps. A drought policy Commission should always identify areas of need for research to better understand drought and improve mitigation and crisis response (HMNDP, 2013; Wilhite, 2016).

Step 7: Integration of science and policy. The planning process should help policy-makers understand the technical concerns related to drought. Likewise, both scientists and managers may have little knowledge of existing policies. Integration will also promote interdisciplinary approaches (Wilhite, 2016).

Step 8: Drought policy and plans for awareness and consensus should be publicised, involving people at different levels throughout the process of planning and preparation. There should be proper communication between implementers and the public.

Step 9: Education programmes should be developed. This is to educate all age groups for awareness of drought management. The importance of introducing the management plan in both forms (crisis and risk) to the public is to include the public in the programme. The programme should involve secondary education, small business, industry, water managers, agricultural producers and home owners (HMNDP, 2013; Wilhite, 2016).

Step 10: Drought policy and mitigation plans should be regularly evaluated and revised. Evaluation of ongoing events and post-drought events is essential in policy development (HMNDP, 2013; Wilhite, 2016). Considering the recommendations of Wilhite (2016) study on strategies to properly implement drought policy, a critical appraisal of past and current drought mitigation policies in Nigeria was conducted.

2.12.2. Critical appraisal of policies and efforts made by Nigerian governments to mitigate impacts of drought

As part of effort by the Nigerian Federal Government to combat the problems of desertification and drought, National Action Plan (NAP) was designed in 2005. The plan was designed to help implement the United Nations Convention to Combat Desertification Framework. Sectoral policies were also introduced in efforts to combat drought and desertification. These policies include the National Policy on Environment, the National Agricultural Policy, the National Environmental Action Plan (NEAP), State Environmental Action Plans (SEAPs) and the National Conservation Strategy. All these are to effectively implement the NAP (FGN, 2005). In 2005, the Federal Government developed a national drought forecasting and Early Warning Systems as part of an effort to mitigate drought

through proactive measures, to facilitate effective drought mitigation measures (FGN, 2005). The Federal Government approved the provision of state-of-the art meteorological instrumentations in many locations to help forecast drought (FGN, 2005). Furthermore, the Federal Government upgraded the status of the Nigeria Meteorological Services to Agency (FGN, 2005). The Federal Government has according to the Constitution, annually reserved 2% of the national budget as ecological funds (FGN, 2005). These funds are disbursed to state governments after application and meeting the criteria of accessing the funds. They are also regarded as contingency funds, where states apply when the have severe environmental problems. Despite the ecological funds, funding remains an issue when it comes to ecological projects (FGN, 2005).

Nwokocha (2017) examined the challenges to effective implementation of drought and desertification strategies adopted by the government in the north-eastern states, including Adamawa, Bauchi and Gombe. The study chose those states considering that they have similar characteristics of drought and desertification. The findings identified challenges which include poor funding, escalated desertification activities by citizens, mismanagement of facilities by citizens, local communities not properly involved in the process, poor commitment from government staff and lack of awareness amongst local citizens (Nwokocha, 2017). The study did not identify which policies were implemented in these states. There are several policies identified by the Federal Government in the 2005 UNCCD report. Considering the choice of study area, it appears that Nwokocha (2017) did not use states severely affected by drought and desertification in the region. Adamawa, Bauchi and Gombe States are moderately affected by drought and desertification (Olagunju, 2015; Table 1.1). Table 2.5 shows how the Federal Government has taken steps to combat drought and desertification by introducing several policies; with implementing ministries and agencies.

Table 2.5: Policies established within the Nation Action Plan (NAP)

S/no.	National Policy/Plan Strategy	Content of NAP-related objectives/activities	Implementing Ministries/Agencies	Actions
1	National Policy on Environment 1989 reviewed in 1999 and 2005.	Drought & desertification is a key prioritised area based on participatory process consistent with NAP	Federal Ministry of Environment as Lead Implementing Ministry, Other Line Ministries and Agencies such as Fed. Ministries of Agriculture, Finance, Water Resources, Education, Information, Energy Commission of Nigeria, and Nigerian Meteorological Agency (NiMET).	This policy deals with issues including biological diversity, conservation of natural resources, land-use and soil conservation, agriculture, water resources, forestry, wildlife and protected areas, mining and mineral resources, energy, education, science and technology, flood and erosion control and cross- sectoral issues of public participation.
2	National Agricultural Policy	Protection of agriculture against drought, desertification, soil erosion and flood. Protection and conservation of forests. Promotion of alternative sources of energy.	Federal Ministry of Agriculture as Lead Agency. Other Federal Line Ministries and Agencies (Environment, Water Resources, Women Affairs, Industries, Finance, Education, Science & Technology, Energy Commission of Nigeria) Nigerian Meteorological Agency (NiMET)	This policy should cover issues that deal with livestock, forestry, food production, and land and water resources, drought, desertification, soil erosion and floods and the Protection and conservation of forests; forest regeneration/ afforestation; ensuring water resources management, conservation and protection of the ecosystem and the promotion of appropriate farming systems.
3	National Environmental Action Plan (NEAP) and State Environmental Action Plans (SEAPs) started 1995 completed in 1998.	Overall Protection of the Nigerian Environment, Conservation of threatened flora and fauna species, Environmental education and awareness creation and reduction of resource use conflict among land users.	Federal and State Ministries of Environment as Lead Agencies, Other Line Ministries and Agencies (Federal Ministries of Agriculture, Education, Water Resources, Finance, Energy Commission of Nigeria, Women Affairs).	The National Environmental Action Plan was developed in order to help analyse, evaluate and discuss interdependence between the environment and Nigeria economy.
4	National Conservation Strategy	Conservation of forest, marine, fisheries, forage, wildlife and soil resources. Application of indigenous knowledge system in conservation of natural resources.	Federal Ministry of Environment as Lead Agency. Other Line Ministries and Agencies (Agric., Education, Women Affairs, Commerce, Industries.	This policy also deals with protection of important ecosystems in Nigeria, especially habitat wildlife.

The Federal Governments has invested in mitigating the effects of drought and desertification in northern Nigeria (Nwokocha, 2016). The investments are through; tree planting, dams for irrigation in affected communities and the establishment of River Basin Authorities for their management (Nwokocha, 2016). Most interventions have not been effective in mitigating the impacts of drought (Nwokocha, 2016). Construction of dams in northern Nigeria has been an issue for decades, as most objectives have not been achieved (YSG Report, 2010). Due to poor management of dams and decreased rainfall in the region, peoples' livelihood down-stream have been adversely affected (YSG Report, 2010). Many farmers and fishermen in Yobe State have been affected by the construction of the Tiga-Challawa Dam in the north-west of the region (YSG Report, 2010). The water normally flows in the River Kamadugu and River Yobe, but after the dam construction in the 1970s, down-stream areas were seriously affected (YSG Report, 2010).

It is important to take appropriate measures and proper consultation before commencing dam construction. This will help understand how the project affects communities in the riverine areas (YSG report, 2010). The study also recommended some drought mitigation measures, stating that government should support rural farmers, proper forest management and comprehensive policies (Nwokocha, 2016). Awareness and protection of marginal lands are some of the remedies recommended by Olagunju (2015). These remedies are important, but a rather comprehensive approach needs to be adopted to arrest problems of drought. Eludoyin *et al*. (2017) reported that drought mitigation should include policy, institutional, socio-economic, physical, community and individual efforts, which was based on review of different national policies. In contrary the Nwokocha (2016) suggested that agroforestry and awareness are remedies to drought in northern Nigeria. However, governments at all levels in Nigeria find it difficult to implement policies (Nwokocha, 2016, 2017, Olagunju 2015 and Medugu, 2009).

Several policies and programmes have been implemented by the Nigerian Government to combat desertification. These include the Arid Zone Afforestation Protection in (1977), River Basin Development (RBDA) (1987) and the establishment of the Federal Environmental Protection Agency (FEPA) in 1987. All 36 states have also established State Environmental Protection Agencies (SEPA) following FEPA guidelines (Medugu, 2009). In 1999, the Department of Drought and Desertification Amelioration was created under the Federal Ministry of Environment. This was to help coordinate policy implementation and monitoring of mitigation strategies (Olagunju, 2015). Most policies identified by FGN (2005) are overseen by this Department.

Despite these policies and programmes implemented by the government problems of drought and desertification has been aggravated over recent years (Medugu, 2009). The government has collected loans and sought partnerships with local and international organisations (Medugu, 2009). They have also received financial and technical support, capacity building and partnership from the Chinese Government, UNEP, Japan International Agency, UNDP, International Fund for Agricultural Development (IFAD) and the World Bank (Medugu, 2009). This might be because the problems are treated as sectoral issues, rather than using integrated approaches to help formulate suitable policies and strategies. Lack of political will, weak institutions and corruption are also linked to the lack of success (Olagunju, 2015; Nwokocha, 2016). Failures of government in drought and desertification policies in Nigeria include neglect of indigenous knowledge, use of inappropriate technology, sectoral approaches, top-down approaches, lack of proper funding and inadequate awareness (Medugu *et al*., 2008).

Population growth, grazing patterns, poverty and weak institutions are also identified as factors that caused failures to policies (Adogi, 2012). The policies highlighted include the National Committee on Arid Zone Afforestation Project in 1977 and the National Policy on

Environment 1988 (Adogi, 2012). However, some northern States have recorded some successes. These include north-western states of Jigawa, Zamfara, Sokoto and Katsina. The successes recorded are in terms of tree planting campaigns, where the trees were managed according to the framework provided by government policies. Nurseries were managed by people in the communities and incentives were given (Adogi, 2012).

The Nigerian government is among 11 countries that introduced the 'Great Green Wall for the Sahara and Sahel Initiative' (GGWSSI). The project was initiated to combat desertification, by building a wall of trees across the Sahara and Sahel (FME, 2012). The wall is expected to be 15 km wide and 7,775 km long from Dakar to Djibouti (Figure 2.6). The project also serves as ecosystem protection and means of sustainable development (FME, 2012). Some of the project's achievements include public awareness on desertification, rehabilitation of ~1200 hectares of degraded land and improving the livelihoods of ~6 million people in some affected communities (FME, 2012). However, there are some challenges, which include population growth, urbanisation, dwindling natural resources caused by anthropogenic activities (FGN, 2005).

People in Gursulu village in Yobe State (Yunusari LGA) have participated in a desertification awareness programme organised by the Federal Government (Gbahabo, 2011). The study interviewed people from the village, which was chosen because it is severely affected by desert encroachment. People from Gursulu stated that their major challenges include rainfall scarcity, lack of basic social amenities, infrastructure and poor access to the village due to poor road conditions (Gbahabo, 2011). Jenkin (2012) also stated that socio-economic activities and infrastructure reduce drought impacts as affected individual would have alternatives.

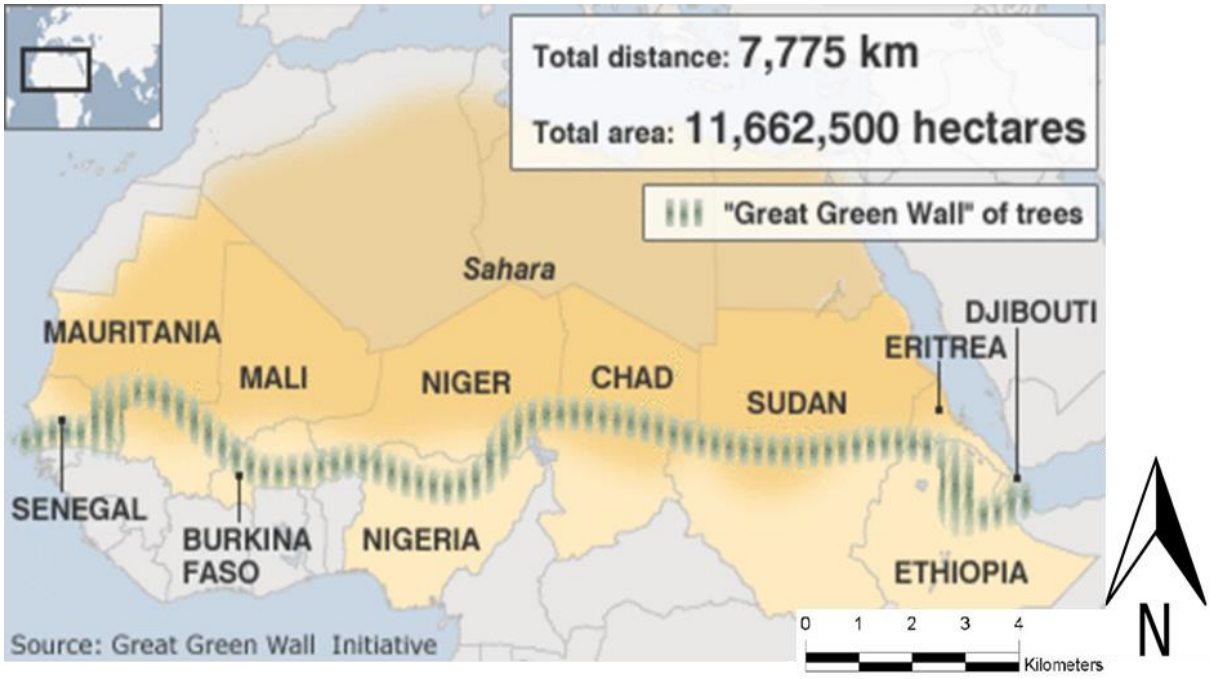

Figure 2.6: The Great Green Wall Project of the Sahara and Sahel (Source: International Tree Foundation (ITF), 2017).

The Nigerian government had invested ~$3 billion in irrigation and drainage facilities, including 300 dams and reservoirs (Abubakar and Yamusa, 2013). The Nigeria government has established food and grain reserves (the Federal Ministry of Agriculture). The National Food Reserve Agency tries to reduce effects of food insecurity and shortages. The reserve has 12 silos with a total storage capacity of 350,000 tonnes, located in different regions (Abubakar and Yamusa, 2013).

Yobe State suffered during the great Sahel drought of the 1970s (Fintell, 2018). The Federal, Borno and Yobe State governments, in partnership with the EU, initiated the 'North East Arid Zone Development Programme' (NEAZDP) to rebuild some rural communities devastated by droughts and poverty. The headquarters was situated in Garin Alkali, Bade LGA in Yobe State. NEAZDP did have some success in terms of agricultural development in Yobe State. However, the EU ended its counterpart funding in 1995 and the Federal Government withdrew funding in 2002 (Fintell, 2018).

The Programme was faced with underfunding afterwards (Mato, 2016). Some NEAZDP projects include small irrigation, animal fattening, sand dune fixation, livestock rearing, education, primary healthcare improvement and seedling distribution (Fintell, 2018; Mato, 2016). Both studies agreed that the NEADZP programme was successful in achieving set objectives. They attributed the success to good organisational structure, evaluation and monitoring strategy (Fintell, 2018; Mato, 2016). However, there is no comprehensive report that highlights and evaluates the successes and failures of most government policies in Nigeria.

2.13. Gaps identified based on literature review and critical appraisal of Nigeria approach

After reviewing literature on drought in different countries and Nigeria, it can be inferred that drought has not received due attention in Nigeria. Drought made farmers in Africa and Nigeria vulnerable in the 1970s some became environmental refugees (Mortimore, 1989). Most studies in Nigeria have mainly focused on desertification. Drought mitigation policies in the Nigeria have mostly failed (Medugu, 2009; Nwokocha, 2016; Olagunju, 2015). Most government policies and strategies are introduced at Federal level currently none of the severely affected States has drought mitigation policies and strategies that suits their needs (Oladip, 1993; Nwokocha, 2016). Despite Federal Government's effort of introducing policies for drought mitigation (FGN, 2005) it has clearly highlighted treating the issue is a major challenge (FME, 2012). The studies of Medugu (2009); Olagunju (2015) and Nwokocha (2016) made recommendations for mitigation, which were not comprehensively reported to show how different measures can be applied in affected areas based on their impacts. The studies have not assessed the level of drought impact in communities affected. No study has reported how stakeholders, proactive measures and proper vulnerability assessment of drought in Nigeria can be used to mitigate drought impacts.

This research ought to assess the level of drought impact in the study area and farmers' coping strategies. Understanding strategies and techniques used in Yobe will help develop better mitigation methods. Considering the approaches used by governments that have been unsuccessful, a different approach is required in order to make farmers more self-reliant. This research has classified all impacts and effects of drought into three sectors: social, economic and environmental, in order to help understand and conduct proper assessments. Thus the preliminary conceptual framework of this research was designed to incorporate the different effects of drought (Figure 7.1). The assessment on these effects will be conducted through empirical study, methodology and methods applied are reported in Chapter 3.

2.14. Summary

Literature reported that impacts of drought severity and frequency have increased over time. The numbers of non-climate related disaster events have remained over the past 3 decades, but weather related events have more than doubled. There is risk of recurrent drought and other related disasters in the future. Drought caused hundreds of thousands of environmental refugees in some parts of the world, (e.g. Somalia, Ethiopia, Kenya, South Africa). Communities in Sub Saharan Africa have become vulnerable due to severe drought within the region, due to poor agricultural practises and land use change, which exacerbate drought impacts. Furthermore some studies show that it takes time for communities and individuals to recover from drought shock. There is difficulty in coping with such drought shock, where selling collateral does not compensate for loss. In turn, these effects have caused both socio-economic and environmental problems in Africa, especially northern Nigeria. This shows that proactive drought mitigation measures are needed.

Climate change and related problems must be mitigated through proactive measures and collective efforts. It is understood that climate change can be mitigated by adapting climate sensitive projects. Some countries (e.g. Australia, Mexico, Spain and South Africa) are

making efforts to shift from traditional methods of drought impact mitigation. The strategies followed by the countries are mostly proactive, for example EWS, preparedness planning, general inclusiveness and reactive measures. Wilhite (2016) highlighted 10 major steps in adopting a robust National Drought Policy. Critical review of drought mitigation policies and strategies in Nigeria showed no much positive progress was made in recent decades. This has also shaped the questionnaire design for this research. In order to achieve aim 1 and its objective 2 of the research, appropriate methods have been chosen and applied.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

Aim 1 is to assess the level of drought impacts on farmers in Yobe State and investigate how they respond to drought. This chapter introduces approaches and methodologies employed in collecting and analysis data. A mixed methods approach was used to gather information used to develop the integrated framework as the final outcome of the study. Evidence of research validation of the study is presented in this chapter. Both internal and external research validation methods are discussed.

3.2. Research design and approach

Research design is the process that guides researchers in conducting their research. It also helps in structuring and designing methodology, methods of data collection, analysis and interpretation (Yin, 1994). Research design is only the methods of data collection and analysis and do not include methodology (Saunders *et al*., 2012). There is however a general acceptance that research design provides the framework that covers the general sequence that connects the initial research questions and the conclusions of the research and relates to the means of data collection and analysis (Yin, 1994; Bryman, 2008). In terms of research design, many studies have highlighted mainly two types of designs for social science research; the deductive and the inductive research design (Cohen *et al.,* 2007; Creswell, 2009, 2014). The deductive approach mainly deals with testing hypotheses or theories and starts with theory and hypotheses, before data collection. Inductive approach is the opposite of the deductive approach. Inductive approaches use participants' views to develop theories and explore new phenomena (Creswell and Plano-Clark, 2007). In interdisciplinary research, it is important to select suitable methods based on the factors mentioned above (Amaratunga *et al*., 2002).

3.3. Mixed methods

The use of mixed methods in research has increased (Sandelowski, 2000). Mixed methods integrate both methods (quantitative and qualitative) to have more complete understanding of the investigated problem. It ensures no important information is excluded (Denscombe, 2007; Creswell, 2009). In this method, data gathering is in sequence, depending on the research approach used (Creswell *et al*., 2003). However, in some cases data are collected concurrently or simultaneously, but this section focuses on sequential methods (Creswell, 2014). There are two sequences of data collection used in this method including:

Sequential mixed explanatory: Is where first quantitative data are collected (questionnaire survey) and analysed. Secondly, qualitative data (Focus Group Discussion FGD or interviews) are also collected and analysed.

Sequential mixed exploratory: This is the opposite sequence to the previous one. Qualitative data are collected and analysed first and then followed by quantitative data collection and analysis (Creswell, 2014). The mixed method provides reliable and valid research outcomes (Creswell, 2007). In the mixed methods approach there should be complementary strengths to make the research reliable (Creswell, 2014). An advantage of the mixed methods design is that they provide an opportunity for detailed quantitative analysis. Important disadvantages of this method are time and resource demands to gather and analyse both types of data (Hanson *et al*., 2005). Most methods employed during mixed methods are quantitative and qualitative (Zou *et al*., 2014) (Table 3.1).

Table 3.1: Comparison of quantitative and qualitative methods

Points of comparison	Quantitative research	Qualitative research
Alternative labels	Positivist, rationalist, functionalist.	Constructivist, naturalistic-ethnographic or interpretive
Scientific explanation	Deductive.	Inductive.
Data classification	Objective.	Subjective.
Objective	To quantify data and generalise results from a sample population.	To understand underlying reasons and motivations. To provide insight into the settings of a problem, generating ideas and/or hypotheses for later quantitative research.
Sample	A large number of cases representing the population of interest. Randomly-selected respondents.	A small number of representative cases. Respondents selected to fulfil a given quota or requirement.
Data collection	Structured interview, self-administered questionnaires, experiments, structure observation, content analysis and statistical analysis.	Participant observation, semi-and unstructured interview, focus groups, conversation and discourse analysis.
Outcome	Used to recommend a final course of action.	Exploratory and/or investigative. Findings are not totally conclusive and cannot always be used to make generalisations.

(Source: Amaratunga *et al*., 2002).

3.4. Quantitative methods

Quantitative research is an investigation used for testing hypothesis based on variables. It is measured numerically and analysed statistically to determine whether to reject or accept a theory or hypothesis (Amaratunga *et al*., 2002). This method is used to explain social phenomena (Bryman, 2008; Zou *et al*., 2014). Researchers choose, based on how accurate the method addresses their problems (Huberman and Miles, 1994). In social science research, survey is the most used technique and was thus used in this research. It is also used to collect opinions of a population and data can be collected using questionnaire (Creswell, 2014). In this research, literature was reviewed and the suitable methods were employed in order to achieve the research aim and objectives. Questionnaire survey is highly suitable technique to collect large data set (Creswell, 2007), thus this research employed the sampling technique. Quantitative methods ideally involve probability sampling to enable statistical inferences (Patton, 1990). Table 3.2 summarises attributes of quantitative methods of data collection.

Table 3.2: Strengths and weaknesses of quantitative research methods

S/No.	Strengths	Weaknesses
1	It tests and validates constructed theories on *how* and *why* phenomena occur.	The researchers' categories might not give clear understanding to local constituencies.
2	It is used to test hypotheses constructed prior to data collection.	The theories used might reflect local constituencies.
3	It is used to generalise research findings, when sufficient random sampling is used.	Researchers miss important phenomena, occurring due to hypothesis testing.
4	It can be generalised and replicated for different population sizes.	Knowledge produced might not be suitable for direct application to some local conditions and individuals.
5	Data collection is faster and quicker than other methods	Limited information acquired
6	Provide numerical and precise data.	No detail of experience and thoughts on the situation in question.
7	Data analysis consumes less time using statistical tools (e.g. SPSS).	Provide figures and numbers only.
8	Results are independent of the researcher's influence.	Researcher is not part of the reality, may tend to miss some important information.
9	It has high credibility with politicians.	Limited credibility with administrators.
10	Used for studying many people.	Cannot be used to study real time situations.

(Source: Huberman and Miles, 1994).

3.4.1. Sample size determination

As discussed above, this research adopted a sequential mixed methods approach (Creswell, 2014). This was achieved through a questionnaire survey (quantitative method) involving farmers in Yobe state who are affected by the problem of drought, followed by a focus group discussion (qualitative method) involving farmers and government officials who had influence on government policy in the State. This section discusses the selection of sample for the research, the design of the research instruments and the process of data collection. Factors to consider include accessibility, time and expenses.

There are no proper data on the number of farmers in the Yobe State. Use of confidence level ensures that the data collected represents the whole population. During sampling, in order to determine the error margin the following confidence level was chosen. The percentage of samples is expected to comprise true population parameters. This research used 99% confidence level (Creswell, 2009). Considering that, the there is no data on total population

of the respondents sample size, 1,040 was used to ensure sufficient data was collected for complete representation on farmer in the State. Research survey are commonly about 20%, which implies that one must disseminate five times the number of questionnaires required for data analysis (Creswell, 2003).

This was designed to avoid sample bias and avoid over/under representation of the targeted test sample group (Yobe farmers). Ezeah and Roberts (2012) used similar method to calculate respondents in in the population of Abuja, but the study used 95% confidence level. Two trained research assistants (natives) were used during the data collection process (Plate 3.1). Hutchinson and Moran (2005), notes that research assistants have been integral part of research work. The Head of the Farmers Association in Machina LGA assisted in facilitating farmers to fill in the questionnaires (Plate 3.2) shows photo of some farmers, researcher and research assistants after a questionnaire distribution and filling session at Yunusari LGA.

Plate 3.1: Researcher with head of Machina Farmers' Association with research team.

Plate 3.2: Cross-section of farmers and the research team.

3.4.2. Pilot study questionnaire testing

Pilot questionnaire testing is important in research, especially during questionnaire design (Munn and Drever, 1990). It is useful in assessing the feasibility, clarity and comprehensiveness of research surveys and can test the rigour and robustness of the survey's methodological framework. It can also be used to ensure validity of responses and help design the final study questionnaire (Pole and Lampard, 2002; Kalutara *et al*., 2018). The study of Kalutara *et al*. (2018) used online Survey Monkey to formulate and amend their final questionnaire.

Due to time, distance and cost constraints, the pilot sample questionnaires of this research were distributed to Nigerian students at the University of Wolverhampton Faculty of Science and Engineering, some 30 questionnaires were administered and 20 were filled and returned (return rate of 66.6%). Final questionnaires were distributed to farmers in Yobe State. As a result of the pilot testing, the main questionnaire was corrected and amended. In the pilot

questionnaire testing, some respondents considered certain questions were too technical and not easy to understand. These include: (i) question on what they (farmers) think can mitigate impacts of excessive irrigation, (ii) what are the steps to improve farmers land use practises (iii) question on if drought causes water scarcity, and (iv) question on if drought causes hunger and death were all removed during the amendment of the final questionnaire. Most questions were chosen based on the reviewed literature on drought, socio-economic and environmental problems in semi-arid Nigeria and other places with a similar climatic regime.

3.4.3. Main questionnaire survey

Questionnaire surveys are widely used to gather information on peoples' opinions and views. Questionnaires usually contain close-ended questions, (e.g. 'Yes'/'No', 'Agree'/'Disagree', and a ranking scale for participants to choose from. There are questionnaires that contain few open questions, which gives respondents free options to choose or write their opinion (Denscombe, 2007; Abubakar, 2013). Questionnaires should be unambiguous, unbiased (Stone, 1993). Some studies use standardised questionnaires, which mean they have to follow a particular format of questions (Denscombe, 2007). Other studies designed and use new questionnaire that suits the purpose of their research. There are no strict rules on how to design a questionnaire, but it is important that the questionnaire addresses the research objective(s) (Smith, 2010).

It is important to use best practises guidelines for designing and administering questionnaire survey (Baker, 2003; Brace, 2008). Best practises to structure questionnaires include clarity, self-guided completion and brief wording which reduces bias or ambiguity (De Vaus, 2007). The main questionnaire was designed following different problems of drought highlighted in the literature review. However, other questions, such as coping strategies employed in the study and social response by respondents, were asked based on the discretion of the researcher.

The questionnaire was divided into four sections: (A) biodata, (B) drought impacts, (C) drought coping strategy and (D) possible mitigation measures. The questionnaire survey distribution started on 8 January 2016 and the final copies were collected on 13 March 2016. The major problems related to postal questionnaire distribution is response rate (Babbie, 1990; Creswell, 2003). Studies that use postal distribution normally receive the response rate between 20-30% in developed countries, which usually have better postal infrastructure than the study area. It was not practical to use postal surveys for this research. Thus, personal administration was employed in this research. Philips *et al*. (2002) and Read *et al.* (2009) used personal administration and received ~98% return rates. This research employed personal administration, due to low levels of literacy in the study area. Responses >25% are considered reliable (Fincham, 2008; Fan and Yan, 2010), thus this research received above the minimum effective rate. There are however advantages and disadvantages of personal survey distribution (Table 3.3).

Table 3.3: Advantages and disadvantages of survey

S/no.	Advantages of personal survey	Disadvantages survey
1	Allows high flexibility in the questioning process.	Higher cost than mail survey.
2	High response rate.	Lack of anonymity; hesitant to disclose personal data.
3	Interviewers have control of interviewing situation.	Biasness of potential participants, due to high flexibility.
4	Possibility of collecting supplementary information.	Time consuming.

(Source: Rubin and Babbie, 2009).

Questionnaire distribution took two months to complete. Respondents from two LGAs (Gujba and Gulani) received their questionnaires in Internally Displaced Persons' (IDP) camps in Damaturu. These respondents were displaced due to the activities of Boko Haram terrorists in north-east Nigeria. Most questionnaires administered in Yobe East and North were distributed at different venues where most farmers were gathered. There are four, four and nine LGAs, respectively, across the regions of the State (Table 3.4).

Table 3.4: List of Local Government Areas (LGAs) in each region

S/no.	Yobe East	Yobe South	Yobe North
1	Damaturu	Fune	Bade
2	Gujba	Potiskum	Nguru
3	Gulani	Nanagere	Machina
4	Tarmuwa	Fika	Karasuwa
5	-	-	Jakusko
6	-	-	Yusufari
7	-	-	Bursari
8	-	-	Yunusari
9			Geidam

(Source: YSG Report, 2010).

There are issues during the questionnaire distribution. For example, some farmers do not want to participate in the survey, whereas in some communities farmers were happy participate. Appendix B presents the revised version of the questionnaire. This research administered 1,040 questionnaires to Yobe State farmers and 721 were completed and returned, a return rate of 69.3%.

3.4.4. Descriptive statistics

All collected questionnaires were coded and transferred into Statistical Package for the Social Sciences (SPSS 2.1) software for analysis. Descriptive statistics was used to analyse the frequency of the respondents on each particular question (Fisher and Marshall, 2009). Responses were cross-tabulated to assess on how the three regions within the State coped with drought. Fisher and Marshall (2009) reported that cross-tabulation can be used to identify patterns during analysis. This information is expected to help in ensuring the appropriate local conditions are taken into consideration for proper planning. Without establishing this, areas of less priority might be considered first for mitigation and intervention. The questionnaires were sent according to the regions and LGAs to help establish that. Microsoft excel was also used to plot average rainfall and crop production graphs for Yobe State between 2008 and 2009.

Rainfall data (2008 and 2009) was sought from National Centers for Environmental Prediction's Climate Forecast System Reanalysis (CFSR) which provides Global Weather Data (GWDS, 2018). Due to lack insufficient meteorological data in the study area, GWD provides meteorological data for many places around the world using high resolution, coupled atmosphere-ocean-land surface-sea ice system to provide the best estimate for a location. This type of data was used in this research due to insufficient weather stations in the study area. Dile and Srinivasan (2014) used the data to develop hydrologic prediction model for river Nile and the data proved reliable. Modu *et al*. (2017) used the same data to predict outbreak of malaria. In this research the data were used to establish the relationship between rainfall and harvest loss in Yobe State.

3.5. Qualitative methods

Qualitative research in social science has increased exponentially from the 1980s (Huberman and Miles, 2002). In this method, researchers generate their own theories based on the truth that, they are part of the reality. The principal aim of qualitative methods is to provide answers to questions such as 'how' and 'why' or develop themes from data, which are usually exploratory in nature (Walker, 1997; Creswell, 2003). The use of qualitative methodologies depends on extent and questions that need to be answered by the study. Qualitative research gives detailed descriptions of people, interactions, events, behaviours, opinions and perspectives (Patton, 1992; Brannen, 1992).

It is also used to discover experience and explore the meaning and reality of situations (Yin, 2003). These are the some of the reasons researchers explore qualitative to gather more information or revalidate of their findings (Creswell, 2003). Data are gathered through conversations, field notes, interviews, photographs, recordings, Focus Group Discussion (FGD) and observations (Denzin and Lincoln, 2005). In this research, FGD was employed. Table 3.5 summarises the strength and weaknesses of qualitative methods.

Table 3.5: Advantages and disadvantages of qualitative methods

S/No.	Strengths	Weaknesses
1	The aim is more detailed description.	Consumes more time than quantitative method.
2	Researchers have clear idea of what they will be looking for in advance.	Creates bias in research.
3	The design usually takes shape as the research unfolds.	Important variables might be missed from the analysis.
4	It is more subjective than objective.	Outcomes are subjective.
5	Qualitative data are in the form of words, pictures and objects.	All must be analysed, which takes time
6	It is more detailed and information rich.	Too much information at a time.
7	Researcher becomes subject in the matter.	Researcher tends to influence the results.

(Source: Huberman and Miles, 1994).

3.5.1. Focus Group Discussion

After the analysis of data from the quantitative phase, a qualitative phase was undertaken using Focus Group Discussion. Focus Group Discussion (FGD) is a forum of group participants invited to discuss an issue (Kraaijvanger *et al*., 2016). Denzin and Lincoln (1994), defined Focus Group Discussion as a group conservation or interview to collect information. Sizes of Focus Group Discussion vary from small (6-12 persons) to large (12 persons≥) (Denzin and Lincoln, 1994). It is a method of gathering information in a short period of time. Information gathered usually contains ideas, opinions, experiences, perceptions and suggestions of participants in a particular group.

Despite the fact that several studies have been conducted on desertification (FGN, 2005; Gbahabo, 2011; FME, 2012; Elijah *et al*., 2017; Nwokocha, 2017) very few have focused on drought no research has asked for drought victims' opinions of approaches in mitigating drought.

Some objectives of using this technique include:

- Have an interactive discussion on drought mitigation measures.
- Gather in-depth information on drought and revalidate survey results.
- Discuss policy options with officials from the Ministry of Environment.

- Provide an environment that discussants can voice their opinions.

3.5.1.1. Procedure for Focus Group Discussion (FGD)

Kraaijvanger *et al*. (2016) used informant to gather participants. In this research, similar method was employed to select farmers at community level. Some farmers were asked after the survey if they would be interested in participating in the FGD. Most discussants were willing to participate. Two separate FGDs were conducted with farmers and government officials from Ministry of Environment of Yobe State. This was conducted after the assessing the level of drought impact in Yobe State. The sessions ascertained the views of both farmers and officials for suitable drought mitigation measures. Officials were used in order to understand their perspectives on efforts in Yobe State on drought impacts mitigation measures.

A formal letter of invitation (Appendix E) was sent to the Ministry of Environment Yobe State and approval was given by the Commissioner (who subsequently advised the responsible department to inform relevant participants and make arrangements). FGD questions are presented in Appendix D. All farmers at community level that participated gathered in Karasuwa village (Karasuwa LGA). Some also came from neighbouring LGAs. Some 22 farmers were invited and 19 participated in the session. In the analysis, participants were labelled with the letter 'F' for farmers. The Ministry of Environment in Yobe State comprises of experts, policy and decision-makers and the Ministry have departmental Heads. Most Heads are experts in their professions. For example, the Department of Drought and Desertification Control oversees drought issues in the State. During the FGD, the Head of Drought and Desertification was also involved in the session and he is one of the Ministry's policy-makers. The Chief Executive (Commissioner) of the Ministry is a member of the State Executive Council, which is the highest decision making body in the State. In the analysis, all

Ministry participants were labelled with the letter 'D' (for Director). During the FGD sessions, notes, videos and audios were taken and the collected data were transcribed manually and interpreted. FGD data are considered as qualitative (Hsiu-Fang and Shannon, 2005). Content Analysis was used to analyse data collected through FGDs and interviews for framework validation (Hsiu-Fang and Shannon, 2005).

3.5.2. Sessions of the FGDs

FGD is usually guided by a facilitator, during the Yobe FGDs the researcher participated as facilitator (Ezeah, 2010; Omolara, 2013). At the beginning of both sessions, the researcher introduced himself and purpose of the sessions. This also allowed the researcher to clarify that no support or help should be expected after the FGD, especially at the community level. The researcher was able communicate with the discussants as he speaks and understood their language. Other non-native researchers employ interpreters during data collection, this is important if researcher does not understand or speak participants' native language, some important issues raised might be left out or misinterpreted during analysis (Gbahabo, 2011). This technique has limitation for example; discussants can change subjects at some point during session (Kraaijvanger *et al*., 2016). Farmers, during their session tried to change subject by introducing political issues into the discussion. Some participates and moderator had to call their attention to focus on the subject under discussion.

3.6. Research validation

The subject of validity is very important in research as it helps to ensure the replicability of the research to lead to same or similar findings. The subject of validation seeks to ensure confidence in the outcome of a research as a true reflection of the reality (Ezaeh, 2010). These factors can be internal or external factors which are capable invalidating a research outcome or finding. Straub *et al*. (2004) defined validation as the process of assessing if a measure has accurately measured what is required to be measured. The main purpose of

research validation, however, is to give society and researchers high levels of confidence about discovered truths (Straub *et al.*, 2004). Figure 3.2 highlights the strengths and weaknesses of research validity.

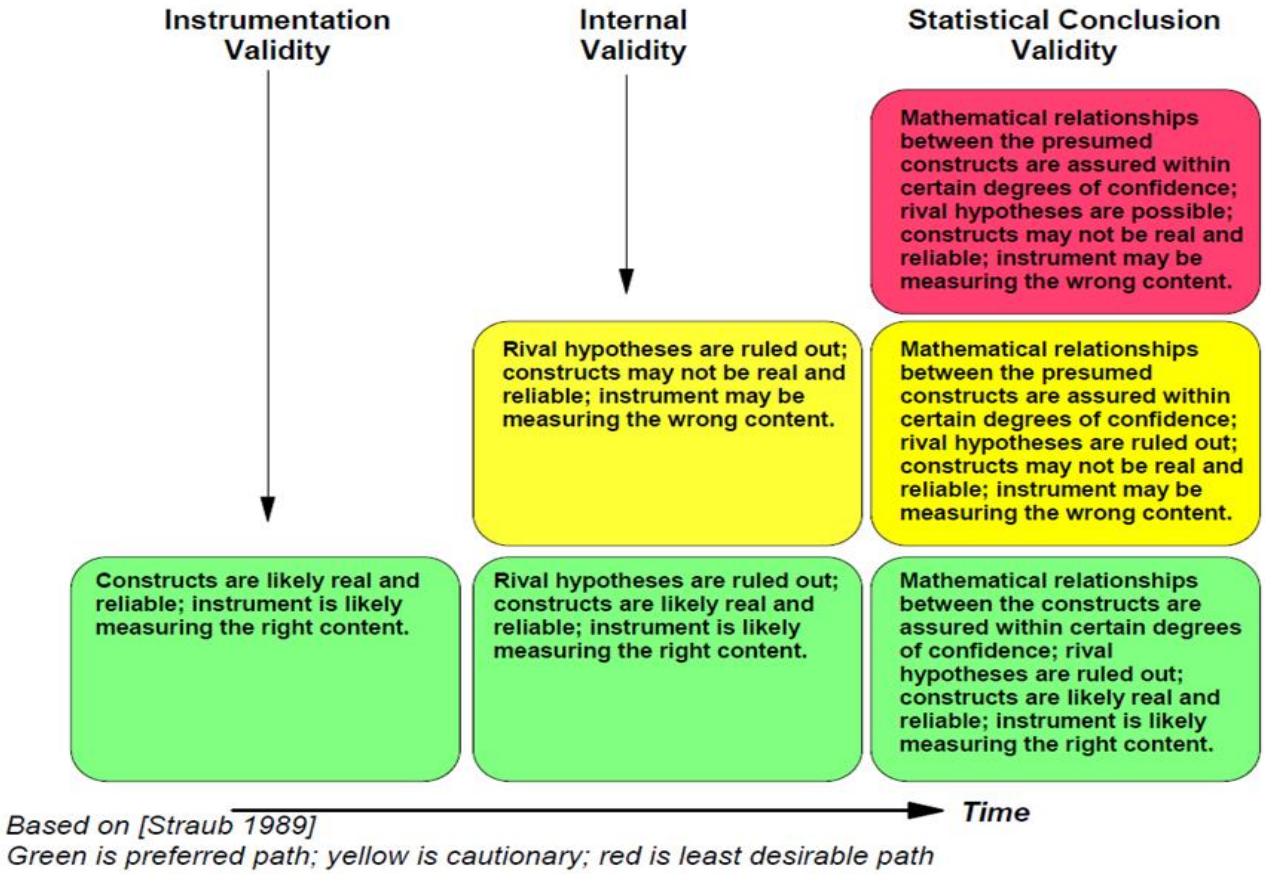

Figure 3.1: Weaknesses and strengths of research findings through validations (Source: Straub, 1989).

There are four types of validation processes, these include: external validity, internal validity, validity of research constructs and validity of statistical findings (Fellows and Liu, 2008). In this chapter, external and internal validations are the main focus.

3.6.1. External validity

External validation is the process of assessing the generality of research findings and means of transforming findings into knowledge (Ankrah, 2007; Abubakar, 2013). External validity is further divided into three, including replication, convergence analysis and boundary search. Replication validity is a process where research processes are repeated to establish whether

the exact findings can be reproduced (Abubakar, 2013). This type of validation can be executed through pilot studies, which were conducted during questionnaire development in this research. Boundary search validity is conducted over time through replication and convergence analysis and is to establish a condition whether research findings are valid. Convergence analysis is the use of different research methodologies in order to validate research findings (Straub *et al*., 2004; Ankrah, 2007). In this research, both quantitative and qualitative methods were employed to validate findings. This method of validation can also be achieved through respondent validation, where research participants' opinions are used in order to verify the validity of research findings (Creswell, 2009).

3.6.2. Internal validity

Internal validation is conducted to ensure that research is free of bias (Gomm, 2008). This research used academic validation through seminars, a journal publication, conferences and workshops. Findings have also been validated through evaluation (i.e. by comparing findings with other studies in discussion and analysis of results). In order to internally validate the questionnaire distributed in Yobe State Cronbach's alpha was used. Cronbach's alpha measures the consistency of each item in a given questionnaire or test in order to establish if they all measure the same construct or characteristics (Retsas, 2000; Garson, 2016; Table 3.6). Cronbach's alpha was used for the reliability test. All scales <0.6 are unreliable, whereas scales >0.70 are reliable (Garson, 2016). The reliability test for this research is 0.781, which is considered statistically reliable.

Table 3.6: Data reliability test questionnaire survey in Yobe State

Reliability Statistics	
Cronbach's Alpha	N of Items (questions)
0.781	33

3.7. Ethical considerations

The subject of ethics is very important in research, especially where the research involves human participants. To ensure all ethical issues of this research are dealt with appropriately before the collection of data, ethical approval was obtained from the University of Wolverhampton Faculty of Science and Engineering Ethics Committee (Appendix A). The confidentiality of participants and data security were ensured and questionnaires were administered in person to participants, who were given the option to cease participation at any time during the process. The participants were assured of anonymity during the analysis and presentation of the research results.

3.8. Summary

This chapter has reviewed literature on research design and methodology and presented the design adopted to undertaken this research. As discussed in this chapter, this research applied mixed methods for data collection. Quantitative methods using questionnaire survey were employed to gather information on drought impacts in Yobe State. Focus Group Discussion was employed to collect detailed information on drought and farmers' perspectives on impacts and mitigation. Officials from the Ministry of Environment (MoE) were also involved in the process. Officials were used in order understand their views on drought in the State and investigate government efforts and measures. Some of the data gathered through the FGD validated the findings of the quantitative survey. The chosen methodologies of the study are thus believed to be suitable. The mixed method was used because it strengthens research outcomes and its considered more reliable. Research validation is also discussed as it was employed to evaluate the frameworks developed for drought mitigation. All the data gathered were analysed and presented in Chapters 4 and 5.

CHAPTER FOUR: DATA ANALYSIS FROM THE QUESTIONNAIRE SURVEY

4.1. Introduction

Aim 1 of the study assesses effects of drought on farmers' livelihood and how drought causes environmental damage in Yobe State. This chapter analysed the questionnaire survey administered to farmers in Yobe State. Open-ended questions were used for in-depth information and were analysed. Samples collected in all the LGAs within the regions in the State are presented and analysed in this chapter.

4.2. Survey data analysis

The 17 LGAs in Yobe State are distributed across the three geographic regions (East, South and North). Table 4.1 represents the distribution, frequency and total number of respondents according to their LGAs in Yobe State. Nguru LGA had 57 respondents, which is the highest, at 7.9% of total responses. Jakusko LGA had the lowest respondents, with 21 respondents

Table 4.1: Local Government Areas where data were collected

L.G.A					
		Frequency	%	Valid %	Cumulative %
	Damaturu	56	7.8	7.8	7.8
	Gujba	31	4.3	4.3	12.1
	Gulani	27	3.7	3.7	15.8
	Tarmuwa	41	5.7	5.7	21.5
	Bursari	39	5.4	5.4	26.9
	Geidam	46	6.4	6.4	33.3
	Yunusari	51	7.1	7.1	40.4
	Potiskum	48	6.7	6.7	47.0
	Nangere	39	5.4	5.4	52.4
	Fune	49	6.8	6.8	59.2
	Fika	28	3.9	3.9	63.1
	Bade	56	7.8	7.8	70.9
	Jakusko	21	2.9	2.9	73.8
	Yusufari	38	5.3	5.3	79.1
	Karasuwa	48	6.7	6.7	85.7
	Nguru	57	7.9	7.9	93.6
	Machina	46	6.4	6.4	100.0
	Total	721	100.0	100.0	-

Table 4.2 reports the frequency and distribution of respondents in Yobe State. East had most responses, followed by North and the South.

Table 4.2: frequency and distribution of respondents in the three regions within Yobe State

Regions				
		Frequency	%	Cumulative %
Valid	East	291	40.4	40.4
	South	164	22.7	63.1
	North	266	36.9	100.0
	Total	721	100.0	-

4.2.1. Respondents' employment status and farming time

Table 4.3 represents the employment status in Yobe State. Most farmers were unemployed and few are employed. Table 4.4 most farmers work as full-time, others practice based on their earnings. In comparison, Ayanlade *et al*. (2018) showed that 85% of study respondents in Southern Nigeria are full-time farmers.

Table 4.3: frequency and percentage of employment

Employed or Not					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	Yes	221	30.7	30.7	30.7
	No	499	69.2	69.3	100.0
	Total	720	99.9	100.0	-
Missing	System	1	0.1	-	-
Total		721	100.0	-	-

Table 4.4: frequency and percentage of farming time

Farming time				
		Frequency of respondents	%	Cumulative %
Valid	Full-time	596	82.7	82.7
	Neither	38	5.3	87.9
	Part-time	87	12.1	100.0
	Total	721	100.0	-

Table 4.5 represents the types of farming respondents usually practise. Most farmers practised rain-fed farming and 23.9% practised mixed-farming (rearing livestock and harvesting crops).

Table 4.5: Types of farming practised

Type of farming				
		Frequency of respondents	%	Cumulative %
Valid	Irrigated farming	51	7.1	7.1
	Rain-fed farming	452	62.7	69.8
	Livestock farming	46	6.4	76.1
	Mixed-farming	172	23.9	100.0
	Total	721	100.0	

4.2.2. Respondents level of drought knowledge

This question was asked as some farmers misunderstand seasonal dry spell and drought. Generally, most had good drought knowledge. Table 4.6 summarizes their understanding. 97.5% of the respondents had good to extremely good knowledge of drought.

Table 4.6: Knowledge of drought

Drought knowledge				
		Frequency of respondents	%	Cumulative %
Valid	Moderate	18	2.5	2.5
	Good	443	61.4	63.9
	Extremely Good	260	36.1	100.0
	Total	721	100.0	-

4.2.3. Respondents as drought victims and people they know

Some 97.9% of respondents considered themselves victims of drought (Table 4.7)

Table 4.7: Number of drought victims

Are you a drought victim?					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	Yes	706	97.9	97.9	97.9
	No	15	2.1	2.1	100.0
	Total	721	100.0	100.0	-

Farmers were asked if they knew other drought victims and they all did (Table 4.8).

Table 4.8: Knowledge of drought victim

Do you know drought victim					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	6-10	5	0.7	0.7	0.7
	11-15	146	20.2	20.4	21.1
	16-20	277	38.4	38.7	59.8
	20 >	288	39.9	40.2	100.0
	Total	716	99.3	100.0	-
Missing	System	5	0.7	-	-
Total		721	100.0	-	-

4.2.4. Respondents harvest loss and impacts of drought on social activities

Some 99% of farmers had moderate to severe harvest loss due to drought (Table 4.9). Most respondents lost their harvests to drought, which accords with the studies by Cooper *et al*. (2008) and Shifarew *et al*. (2014).

Table 4.9: Harvest loss due to drought

Harvest lost				
		Frequency of respondents	%	Cumulative %
Valid	Little	8	1.1	1.1
	Moderate	22	3.1	4.2
	High	387	53.7	57.8
	Severe	304	42.2	100.0
	Total	721	100.0	-

Most farmers believed that drought affected their social activities (Table 4.10) which accords with the findings of Habiba *et al*. (2012).

Table 4.10: Effects of drought on social activities

How drought affects social activities (2005-2015)				
		Frequency of respondents	%	Cumulative %
Valid	Moderate	27	3.7	3.7
	High	445	61.7	65.5
	Severely	249	34.5	100.0
	Total	721	100.0	-

4.2.5. Impact of drought on respondents' income and past droughts

Most farmers were highly to severely affected by drought (Table 4.11).

Table 4.11: Effects of drought on incomes

How drought affect income (2005-2015)					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	Moderately	58	8.0	8.1	8.1
	Highly	449	62.3	62.5	70.6
	Severely	211	29.3	29.4	100.0
	Total	718	99.6	100.0	-
Missing	System	3	0.4		-
Total		721	100.0		-

Most farmers believed drought occurred regularly over the past decade (Table 4.12).

Table 4.12: Perceived drought events in the past 10 years (2005-2015)

Past drought events in 10 years (2005-2015)					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	0-2	47	6.5	6.5	6.5
	3-5	328	45.5	45.6	52.1
	6-9	109	15.1	15.1	67.2
	≥10	236	32.7	32.8	100.0
	Total	720	99.9	100.0	-
Missing	System	1	0.1		-
Total		721	100.0		-

4.2.6. Respondents' harvest loss

Farmers were asked to estimate their harvest loss due to drought in the past 10 year and they all believed they had substantial harvest lost (Table 4.13).

Table 4.13: Loss of harvest in the last 10 years (2005-2015)

Loss of harvest in 10 years					
%		Frequency of respondents	%	Valid %	Cumulative %
Valid	30-40	30	4.2	4.2	4.2
	50-60	112	15.5	15.6	19.7
	70-80	381	52.8	52.9	72.6
	90-100	197	27.3	27.4	100.0
	Total	720	99.9	100.0	-
Missing	System	1	0.1		-
Total		721	100.0		-

4.2.7. Responses on how drought affects their income

Most farmers believed drought highly increases food prices (Table 4.14). Other studies have reported similar results (Kinsey *et al*., 1998; Gbahabo, 2011).

Table 4.14: Effects of drought on food prices

Food prices					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	Moderate	69	9.6	9.6	9.6
	Neutral	31	4.3	4.3	13.9
	High	394	54.6	54.7	68.6
	Severely	226	31.3	31.4	100.0
	Total	720	99.9	100.0	-
Missing	System	1	0.1		-
Total		721	100.0		-

4.2.8. Respondents' response to causes of drought and its impacts on livestock

In terms of perceived causes of drought, 45.8% believed it is caused by climate change whereas 53.3% believed it was an 'Act of God' (Table 4.15). Other studies reported similar results (West *et al*., 2008; Habiba *et al.*, 2012).

Table 4.15: Farmers' perception of causes of drought

Farmers' perception of causes of drought				
		Frequency of respondents	%	Cumulative %
Valid	Climate changes	330	45.8	45.8
	'Act of God'	384	53.3	99.0
	None	7	1.0	100.0
	Total	721	100.0	

Farmers were asked how drought has affected their livestock. Most respondents' livestock were very well to extremely affected by drought (Table 4.16).

Table 4.16: Effects of drought on livestock

Effects livestock				
		Frequency of respondents	%	Cumulative %
Valid	Moderate	54	7.5	7.5
	Neutral	2	0.3	7.8
	Very well	383	53.1	60.9
	Extremely	282	39.1	100.0
	Total	721	100.0	

4.2.9. Number of dead livestock

Most farmers have lost considerable number of livestock (Table 4.17).

Table 4.17: Numbers of livestock deaths due to hunger

Numbers of dead livestock				
		Frequency of respondents	%	Cumulative %
Valid	0-5	16	2.2	2.2
	6-10	181	25.1	27.3
	11-15	176	24.4	51.7
	16-20	220	30.5	82.2
	≥20	128	17.8	100.0
	Total	721	100.0	-

4.2.10. Conflict due to drought and harvest storage

Respondents were asked if drought in Yobe State caused conflicts amongst communities and most respondents did believed that drought can highly and very highly cause conflict, respectively, in and amongst communities. This shows the importance of mitigating drought as Daily Trust (2018) reported similar results. Respondents were asked on how they reduce recurrent drought shock. Most farmers are able to store some of their harvests due to their social status, whereas other could not store as they can harvest very little due to their financial strength (Table 4.19). Some farmers sell their harvest to pay for their expenses and loans after the rainy season, which can also cause conflict if someone is unable to pay their debt due to harvest loss.

Table 4.18: Effects of drought on conflict

Causes of conflict				
		Frequency of respondents	%	Cumulative Percent
Valid	Little	3	0.4	0.4
	Moderate	98	13.6	14.0
	Neutral	8	1.1	15.1
	Highly	389	54.0	69.1
	Very highly	223	30.9	100.0
	Total	721	100.0	-

Table 4.19: Storage of harvest to protect from impacts of drought

Harvest storage				
		Frequency of respondents	Percent	Cumulative Percent
Valid	I do not store	144	20.0	20.0
	When drought is frequent	267	37.0	57.0
	Never	244	33.8	90.8
	Always store	66	9.2	100.0
	Total	721	100.0	-

4.2.11. Respondents' drought coping strategies

The research sought to understand how respondents cope with droughts. In table 4.20, some farmers said they reduce their area of harvest during drought, whereas most said they sell their harvest to compensate for drought shock and some said they migrate.

Table 4.20: Yearly drought coping strategies

Drought coping strategies					
		Frequency of respondents	%	Valid %	Cumulative Percent
Valid	Reduce area of harvest	159	22.1	22.1	22.1
	Sell stored harvest	303	42.0	42.2	64.3
	Sell livestock	38	5.3	5.3	69.6
	Migration	206	28.6	28.7	98.3
	Do not harvest	12	1.7	1.7	100.0
	Total	718	99.6	100.0	-
Missing	System	3	.4	-	-
Total		721	100.0	-	-

4.2.12. Livestock for drought compensation

Table 4.21 summarises if the respondents agree or disagree that livestock sales can compensate for drought shock. Some 95.6% strongly disagreed and disagreed. Farmers often use livestock as buffer in Africa to reduce drought shock (Fafchamps *et al*., 1998). However, it is evident that farmers in Yobe State do not believe that livestock serves as a buffer for drought shock. Droughts cause livestock death and reduce their value (Gautier *et al*., 2016).

Table 4.21: Livestock sales compensate impacts of drought

Livestock sales to compensate lost				
		Frequency of respondents	%	Cumulative %
Valid	Strongly disagree	451	62.6	62.6
	Disagree	238	33.0	95.6
	Do not know	9	1.2	96.8
	Agree	21	2.9	99.7
	Strongly agree	2	0.3	100.0
	Total	721	100.0	-

4.2.13. Respondents' coping strategy for persistent drought and irrigation practise

There was a need to assess drought coping strategies if drought persists in Yobe State. Some 77.5% of the respondents over-harvest their farms and cut down trees to sell fuel-wood if drought is persistent with the aim of obtaining more yields and reduce shock (Table 4.22).

Table 4.22: Coping strategies if drought persists

Coping strategy if droughts persists				
		Frequency of respondents	%	Cumulative %
Valid	Over-harvest farm	333	46.2	46.2
	Hunt wild animal	24	3.3	49.5
	Cut down trees	226	31.3	80.9
	Resort to fishing	138	19.1	100.0
	Total	721	100.0	-

Table 4.23 reports respondents' views of irrigation as an alternative to mitigate drought impacts. Most farmers believed that irrigation is always an alternative. Plate 4.1, shows how farmers collect fuel-wood around an irrigated farm in Yobe north. Farmers have collected

wood, which they will use it for cooking and other utilities.

Table 4.23: Irrigation as an alternative if drought persists

Is irrigation an option?					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	It is an alternative during drought	84	11.7	11.7	11.7
	It is always an alternative	631	87.5	88.0	99.7
	In rare cases	2	0.3	0.3	100.0
	Total	717	99.4	100.0	-
Missing	System	4	0.6	-	-
Total		721	100.0	-	-

Plate 4.1: Irrigation area in North Yobe in Gashua, Bade LGA (Researcher's photo).

4.2.14. Respondents' dependency on the natural environment

Table 4.24 reports if respondents believe drought causes dependency on the natural environment as farmers' coping strategy. All 100% of responses believed drought causes direct dependency on the natural environment.

Table 4.24: Drought and it's the dependency on environment

Drought cause dependency on the environment				
		Frequency of respondents	%	Cumulative Percent
Valid	Yes	721	100.0	100.0

4.2.15. Drought and environmental damage

There was need to investigate if poverty causes environmental damage in Yobe State. Table 4.25 showed that 88.5% believed that drought causes severe and very severe environmental damage. Plate 4.2 is an example of harvested farm land in Yunusari LGA in the northern part of the Yobe State bordering the Niger Republic.

Table 4.25: Poverty causes environmental damage

Poverty causes environmental damage					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	Moderate	83	11.5	11.5	11.5
	Severe	307	42.6	42.7	54.2
	Very severe	329	45.6	45.8	100.0
	Total	719	99.7	100.0	-
Missing	System	2	.3	-	-
Total		721	100.0	-	-

4.2.16. Responses on increased desertification

Some 98.5% of respondents believed that drought causes desertification (Table 4.26).

Table 4.26: Drought and desertification

Drought causes desertification?				
		Frequency of respondents	%	Cumulative %
Valid	Yes	710	98.5	98.5
	No	11	1.5	100.0
	Total	721	100.0	-

Plate 4.2: Harvested farmland in Yunusari LGA, Yobe north (Researcher's photo).

Table 4.27 reports if respondents noticed increased desertification due to increased drought frequency. Some 61.9% of respondents believed that desertification had seriously increased due to frequent drought, while 33.7% believed that desertification had increased.

Table 4.27: Increased desertification

Increased desertification				
		Frequency of respondents	%	Cumulative %
Valid	Seriously increased	446	61.9	61.9
	It has increased	243	33.7	95.6
	Not increased	5	0.7	96.3
	I have not noticed	27	3.7	100.0
	Total	721	100.0	-

4.2.17. Drought social welfare and infrastructure

Respondents were asked if improved infrastructure and social welfare will reduce the effects of drought and the vast majority agreed (Table 4.28).

Table 4.28: Improved social amenities and welfare

Improved social welfare and infrastructure				
		Frequency of respondents	%	Cumulative %
Valid	Disagree	17	2.4	2.4
	Do not know	1	0.1	2.5
	Agree	279	38.7	41.2
	Strongly agree	424	58.8	100.0
	Total	721	100.0	-

Table 4.29 summarizes if respondents believe that governmental non-governmental interventions can mitigate the impacts of drought. Most respondents believed that interventions would reduce drought impacts.

Table 4.29: Effects of interventions on drought victims

Government and non-government intervention					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	Disagree	47	6.5	6.5	6.5
	No idea	1	0.1	0.1	6.7
	Agree	219	30.4	30.4	37.1
	Strongly agree	453	62.8	62.9	100.0
	Total	720	99.9	100.0	-
Missing	System	1	0.1		-
Total		721	100.0		-

4.2.18. Responses of interventions received and required

Table 4.30 shows most farmers had never received drought relief before and did not know who was given relief. Respondents were asked if government support, such as loans would mitigate the impacts of drought and most agreed that loans will reduce impacts (Table 4.31).

Table 4.30: Drought relief for victims

Relief to victims					
		Frequency of respondents	%	Valid %	Cumulative %
Valid	Never had relief	484	67.1	67.2	67.2
	Do not know anyone who received relief	236	32.7	32.8	100.0
	Total	720	99.9	100.0	-
Missing	System	1	0.1		-
Total		721	100.0		-

Table 4.31: Would government and private loans mitigate drought?

Loans from government and private sector				
		Frequency of respondents	%	Cumulative %
Valid	Disagree	31	4.3	4.3
	No idea	13	1.8	6.1
	Agree	307	42.6	48.7
	Strongly Agree	370	51.3	100.0
	Total	721	100.0	-

4.2.19. Cross-tabulation of past drought events and regions

Table 4.32 represents the cross tabulation of past drought events according to regions. Drought is more frequent in the North, followed by Yobe East and then Yobe South.

Table 4.32: Cross tabulation of past droughts and regions

Regions and Past drought events in 10 years (2005—-2015)							
			Droughts in past 10 years				Total
			0-2	3-5	6-8	>10	
Regions	Yobe East	Count	28	217	4	42	291
		% within drought events in 10 years	59.6	66.2	3.7	17.8	40.4
		% of Total	3.9	30.1	0.6	5.8	40.4
	Yobe South	Count	19	101	44	0	164
		% within drought events in 10 years	40.4	30.8	40.4	0.0	22.8
		% of Total	2.6%	14.0	6.1	0.0	22.8
	Yobe North	Count	0	10	61	194	265
		% within drought events in 10 years	0.0	3.0	56.0	82.2	36.8
		% of Total	0.0	1.4	8.5	26.9	36.8
Total		Count	47	328	109	236	720
		% within regions	6.5	45.6	15.1	32.8	100.0
		% of Total	6.5	45.6	15.1	32.8	100.0

4.2.20. Cross-tabulation of harvest loss according to regions

Cross tabulation was performed to assess which regions were most affected by harvest loss. Table 4.33 shows that Yobe North lost more harvests than the other regions, as 256 of 266 responses showed harvest loss was severe, Yobe South was least affected. Cross tabulation shows that regions have different drought coping strategies (Table 4.34). Sales of stored harvest was the preferred strategy in Yobe East, livestock sales were preferred in the South, and migration most chosen option in Yobe North.

Table 4.33: Cross tabulation for regions and harvest loss

Regions and Rate harvest loss							
			Harvest loss				Total
			Little	Moderately	Highly	Severely	
Regions	Yobe East	Count	0	0	248	43	291
		% within region	0.0	0.0	85.2	14.8	100.0
		% within Rate harvest lost	0.0	0.0	64.1	14.1	40.4
		% of Total	0.0	0.0	34.4	6.0	40.4
	Yobe South	Count	8	22	129	5	164
		% within region	4.9	13.4	78.7	3.0	100.0
		% within Rate harvest lost	100.0	100.0	33.3	1.6	22.7
		% of Total	1.1	3.1	17.9	0.7	22.7
	Yobe North	Count	0	0	10	256	266
		% within region	0.0	0.0	3.8	96.2	100.0
		% within Rate harvest lost	0.0	0.0	2.6	84.2	36.9
		% of Total	0.0	0.0	1.4	35.5	36.9
Total		Count	8	22	387	304	721
		% within region	1.1	3.1	53.7	42.2	100.0
		% within Rate harvest loss	100.0	100.0	100.0	100.0	100.0
		% of Total	1.1	3.1	53.7	42.2	100.0

Table 4.34: Cross tabulation for regions and drought coping strategy

Regions and Cross tabulation of drought coping strategy								
			Drought coping strategy					Total
			Reduce area of harvest	Sell stored stock	Sale livestock	Migration	I do not harvest	
Regions	Yobe East	Count	39	200	19	21	12	291
		% within Regions	13.4	68.7	6.5	7.2	4.1	100.0%
		% within Coping strategy of drought	24.5	66.0	50.0	10.2	100.0	40.5
		% of Total	5.4	27.9	2.6	2.9	1.7	40.5
	Yobe South	Count	62	52	19	28	0	161
		% within Regions	38.5	32.3	11.8	17.4	0.0	100.0
		% within Coping strategy of drought	39.0	17.2	50.0	13.6	0.0	22.4
		% of Total	8.6	7.2	2.6	3.9	0.0	22.4
	Yobe North	Count	58	51	0	157	0	266
		% within Regions	21.8	19.2	0.0	59.0	0.0	100.0
		% within Coping strategy of drought	36.5	16.8	0.0	76.2	0.0	37.0
		% of Total	8.1	7.1	0.0	21.9	0.0	37.0
Total		Count	159	303	38	206	12	718
		% within Regions	22.1	42.2	5.3	28.7	1.7	100.0
		% within Coping strategy of drought	100.0	100.0	100.0	100.0	100.0	100.0
		% of Total	22.1	42.2	5.3	28.7	1.7	100.0

4.2.21. Cross-tabulation of desertification within regions

Participants noted increased desertification in Yobe State, especially in Yobe north (Table 4.35).

Table 4.35: Cross tabulation of increased desertification and regions

Cross tabulation of increased drought and regions							
			Increase in desertification				Total
			Strongly increased	It has increased	Not increased	I have not noticed	
Regions	Yobe East	Count	173	113	5	0	291
		% within regions	59.5	38.8	1.7	0.0	100.0
		% of increase in drought	38.8	46.5	100.%	0.0	40.4
		% of Total	24.0	15.7	0.7	0.0	40.4
	Yobe South	Count	17	120	0	27	164
		% of increased drought within regions	10.4	73.2	0.0	16.%	100.0
		% within increase in drought	3.8	49.4	0.0	100.0	22.7
		% of Total	2.4	16.6	0.0	3.7	22.7
	Yobe North	Count	256	10	0	0	266
		% within regions	96.2	3.8	0.0	0.0	100.0
		% of increase in drought	57.4	4.1	0.0	0.0	36.9
		% of Total	35.5	1.4	0.0	0.0	36.9
Total		Count	446	243	5	27	721
		% within regions	61.9	33.7	0.7	3.7	100.0
		% within increase in drought	100.0	100.0	100.0	100.0	100.0
		% of Total	61.9	33.7	0.7	3.7	100.0

Table 4.36 shows cross tabulation on how people cope with persistent drought and number of drought events in the past decade. At ≥10 events, over-harvesting is the main strategy to cope with drought. At 0-2 events, deforestation is the main strategy, whereas at 6-8 events people resort to fishing.

Table 4.36: Cross-tabulation of coping strategy if drought persists verses past 10 years (2005-2015)

Coping strategy if drought persist versus Past drought events in 10 years Cross tabulation							
			Past drought events in 10 years				Total
			0-2	3-5	6-8	≥10	
Coping strategy if drought persist	Over-harvest your farm	Count	8	158	5	161	332
		% if droughts persist	2.4 %	47.6	1.5	48.5	100.0
		% of past droughts in 10 years	17.0	48.2	4.6	68.2	46.1
		% of Total	1.1	21.9	0.7	22.4	46.1
	Hunting wild animal	Count	5	18	1	0	24
		% if droughts persist	20.8	75.0	4.2	0.0	100.0
		% of past droughts in 10 years	10.6	5.5	0.9	0.0	3.3
		% of Total	0.7	2.5	0.1	0.0	3.3
	Cut down trees	Count	29	129	50	18	226
		% if droughts persist	12.8	57.1	22.1	8.0	100.0
		% of past droughts in 10 years	61.7	39.3	45.9	7.6	31.4
		% of Total	4.0	17.9	6.9	2.5	31.4
	Resort to fishing	Count	5	23	53	57	138
		% if droughts persist	3.6	16.7	38.4	41.3	100.0
		% of past droughts in 10 years	10.6	7.0	48.6	24.2	19.2
		% of Total	0.7	3.2	7.4	7.9	19.2
Total		Count	47	328	109	236	720
		% if droughts persist	6.5	45.6	15.1	32.8	100.0
		% of past droughts in 10 years	100.0	100.0	100.0	100.0	100.0
		% of Total	6.5	45.6	15.1	32.8	100.0

4.3. Analysis of average rainfall and crop production in Yobe State

According to the results from table 4.13 it can be established that drought has caused harvests losses in the State. In order to establish if rainfall has influenced crop production as estimated by the respondents, further statistical analyses were conducted. Table 2.3 presented the difference between 2008 and 2009 crop production in 17 LGAs of Yobe State, 2008 and 2009 rainfall data were collected from Global Weather Data (GWDS) to conduct an analysis using

data from Table 2.3 and GWDS data. Table 4.37 presents the average rainfall and crop production of 2008 and 2009 in Yobe State.

Table 4.37: 17 LGAs' 2008 and 2009 average rainfall and crop production in Yobe State

Locations	Average rainfall 2008 (mm)	Average rainfall 2009 (mm)	Crop Production 2008 (t)	Crop Production 2009 (t)
Bade	173.3056	59.85878	301.40	198.60
Bursari	220.5265	94.65134	311.30	123.20
Damaturu	306.747	197.4783	672.50	386.40
Fika	256.6281	172.5706	698.40	455.20
Fune	349.2423	241.6334	475.00	233.00
Geidam	146.0067	53.35236	766.50	521.20
Gujba	254.7582	185.9953	825.20	522.90
Gulani	168.3996	193.5616	372.30	177.70
Jakusko	260.0204	145.1026	337.40	178.80
Karasuwa	160.6127	79.15472	475.50	305.30
Nangere	283.2497	255.7289	326.40	167.80
Nguru	139.9561	94.04105	212.80	104.30
Machina	127.914	94.14053	841.10	589.50
Potiskum	283.2497	255.7289	831.10	597.20
Tarmuwa	337.8905	199.7978	452.00	265.00
Yunusari	150.4168	52.9432	141.70	75.70
Yusufari	166.2885	56.63957	193.30	89.60

Figure 4.1 presents the 2008 average rainfall and crop production in the 17 LGAs and figure 4.2 presents 2009 average rainfall and crop production of the 17 LGAs respectively. Results from figures 4.1 and 4.2 show that there is difference in rainfall received and total crop production outputs in both years. It shows that 2008 had the highest average rainfall and crop production in the State, whereas 2009 had low rainfall and total crop production. However, the results from both years show that some locations had high rainfall and low crop yield and some locations had low rainfall and high crop yield. For example, in 2008 Machina received 128 mm and had one of the highest crop productions in the State, Potiskum received higher

rainfall than Machina, but there crop production remains the same. Fune received ~300 mm of rainfall, but had low crop production than Machina.

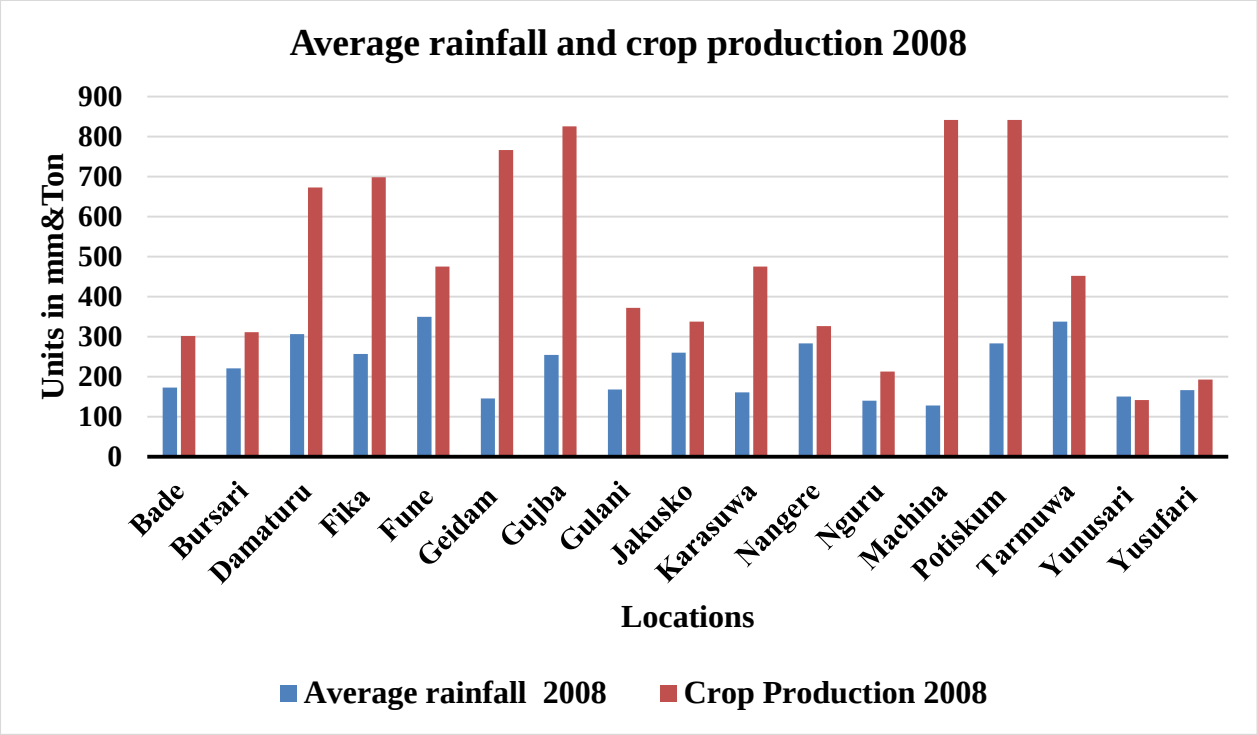

Figure 4.1: 2008 average rainfall and crop production in Yobe State.

In 2009, the results show that there is generally low rainfall received in the State compared to 2008. For example, Machina and Potiskum had the highest crop production, which is lower than that of 2008. However, there are locations that received more rainfall than Potiskum and Machina, but had low crop production, places such as Damaturu, Fune and Nangere.

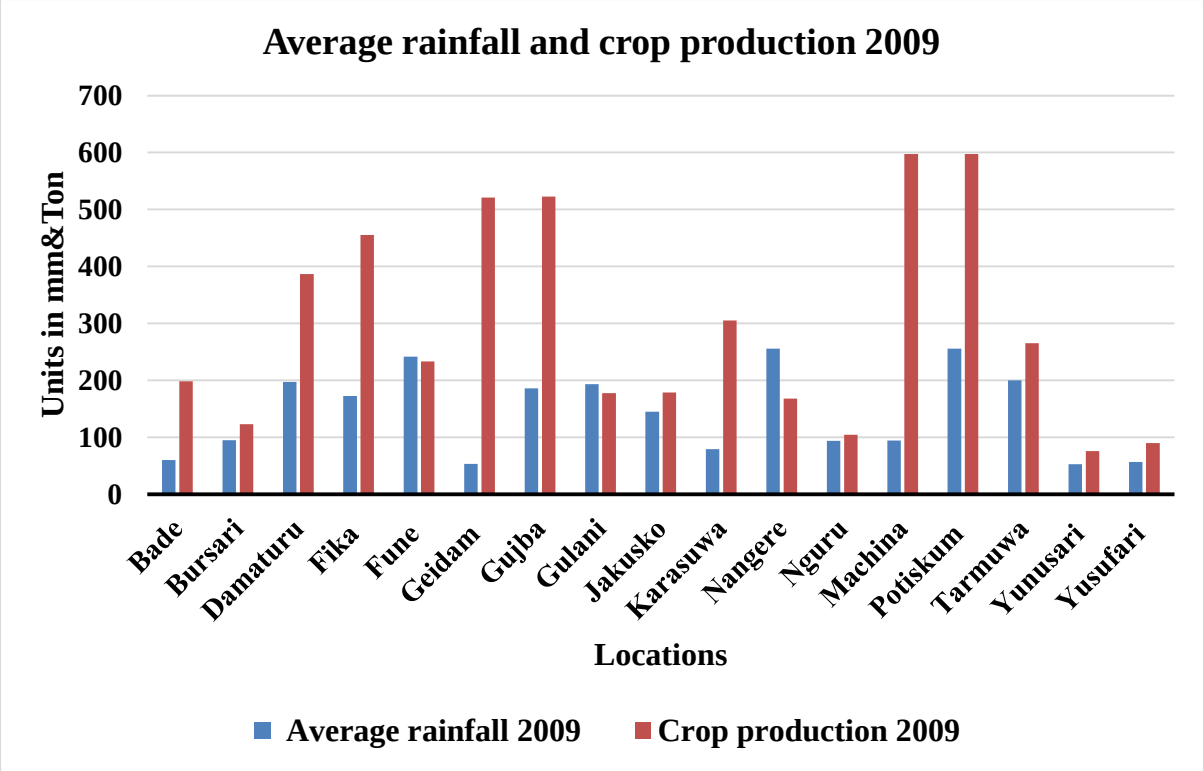

Figure 4.2: 2009 average rainfall and crop production in Yobe State.

4.4. Open ended questions analysis

Table 4.38 shows peoples' opinions on what drought affects, apart from harvest and livestock.

Table 4.38: Selected impacts of drought in Yobe State

S/no.	Impacts	Frequency
1	Water shortage	132
2	Income	407
3	Daily activities	90
Total		**629**

Table 4.39 reports what happens to farmers' livestock if droughts persist. Most responses showed that this leads to livestock malnutrition and the mortality. Similar cases were reported in the Horn of Africa during the prolonged drought of 2012 (Vicente-Serrano*et al*., 2012).

Table 4.39: Impacts of persistent drought on livestock

S/no	Impacts	Frequency
1	Malnourished	104
2	Death	147
Total		**251**

Drought reduces livestock value and the situation makes it difficult for owners to rear and maintain livestock. Respondents were asked what they should do in order to respond to drought within their communities if no intervention was sought (Table 4.40).

Table 4.40: People's response to drought

S/no.	Impacts	Frequency
1	Support each other	145
2	Community collective support	180
3	Urban migration	23
4	Alternative job	70
5	Cut trees	81
6	Sell remaining harvest or livestock	18
7	Cannot support each other/nothing	91
Total		**608**

Many believed that community's collective support should be the main response strategy. Others suggested those that wealthier better off should support the needy. However, some believed that there is nothing they can do to support each other. Deforestation, alternative jobs, selling livestock or harvest and urban migration are the main options. However, it is difficult to seek for alternative jobs, as there are few employment opportunities. Lack of social amenities and infrastructure limits options (Gbahabo, 2011).

4.5. Summary

Analysis of the questionnaire survey investigated the effects of drought and coping strategies in Yobe State. All returned questionnaires were analysed using SPSS 2.1. There are 17 LGAs in the State (South, East and North Yobe State). A total of 721 questionnaires were returned from the 17 LGAs. Yobe East had most responses, with 291 returned (40.4% of the total), where Yobe North had 266 responses (36.9%), and Yobe South had 164 responses (22.7%).

Most farmers (82.7%) are full-time and (69.3%) have no alternative sources of income. Most 53.7% of farmers lost most of their harvest to drought and livestock as well. Focus Group Discussions (FGDs) with experts on environment, farmers and policy-makers were conducted. This was to obtain detailed information for effective drought management, Chapter 5 presents the findings from the FGDs.

CHAPTER FIVE: ANALYSIS OF FOCUS GROUP DISCUSSIONS

5.1. Introduction

In order to help achieve Objective 2 of Aim 2, this chapter presents findings from Focus Group Discussions (FGDs). The FGDs aimed to gather detailed information on impacts of drought and understand people's opinion of how drought mitigation and management should be approached. The FGDs were conducted at two levels, Community (farmers) and Governmental (officials). Analyses were further divided into two; Community level FGD and Government level FGD and results were analysed separately. All presentations in this chapter are responses from the discussants from the community and Ministry of Environment (MoE) of Yobe State.

5.1.1. Responses with farmers at community level

During the FGD with farmers at community level, the survey report was presented after which questions were asked. Farmers were invited to further discuss drought and they all responded that, most of the problems had been dealt with in the presentation of the survey analysis. Strategies of drought mitigation were discussed and opinions were analysed.

5.2. Changes in rainfall patterns in Yobe State

Farmers were of the view that rainfall is their main problem, because they all depend on rain for their harvests and livestock feed. Farmers in Southern Nigeria also defined drought based on the onset and cessation of rainfall, and they stated that this affects their level of production (Ayanlade *et al*., 2018). The rainy season in Yobe State is highly variable (Shiru *et al*., 2018). In some communities, farmers sow their seeds a month or two before the proper rainy season settles in. The farmers stated that in some places, especially Machina LGA, people sow their seeds 60 days before the first rainfall. The soil there does not damage sown seeds, despite the high temperatures and seeds germinate after receiving the first seasonal rainfall. Farmers in the area said that they practise the same method of plantation, but worry that they will have

insufficient rainfall for their seeds to germinate and grow for proper harvest. Others said that, for the past 12 years, they have not had a 'bumper' harvest. The major issue is that when the rainy season starts in most parts of the State, it ceases when plants need water for growth, causing wilting. The process of early sowing at first rain of the season is locally called '*Kiri*.'

It takes ~40 days to receive the second rains in some places, after the first rainfall. However, if the rainy season settles, they also experience gaps of ~12-14 days between rain events. Insufficient yield decreases animal feed and fodder supplies and can lead to livestock mortality. Despite these difficulties, farmers stated that they cannot give up farming, as it is their only means of livelihood. Considering the concern by farmers during the FGD on the lack of rainfall, the 2016 rainy season has been one exception in many years. They received so much rainfall in the year that several building structures were destroyed by heavy rainfall. This was unexpected by farmers, as they have not prepared for such events. If such events are forecast in the future, the rainfall water can be harvested and reserved for irrigation.

5.3. Farmers' contribution to environmental degradation

Farmers agreed that they have contributed to environmental degradation, through bush-burning, over-harvesting, over-grazing and deforestation, as means of sustenance. These activities are what they have practised over many years, to provide alternative sources of income. This is due to insufficient income through their harvest and livestock farming activities. Plate 5.1 below shows cross-session of farmers of different age groups during the community session.

Bush-burning: Is mostly practised prior to the rainy season in many parts of the State. This is where farmers clear their farmlands to prepare for the rainy season. The process affects topsoil components and nutrients, which can also contribute to low crop yields (Olagunju, 2015). Farmers stated that they had no knowledge of the negative impacts of bush-burning.

It is a practise they have learnt from their ancestors. They are convinced that this is the most cost-effective way of clearing farms.

Plate 5.1: Focus Group Discussion with farmers (age group 25-65) researcher's photo.

Over-harvesting and over-grazing: These are practised due to insufficient harvests during the rainy season. Some farmers give their daughter's hand in marriage, usually after the rainy season, when they sell crops to prepare for the wedding after bumper harvests. These play vital roles in people's social life. These occur when farmers remove remains of plants after harvest to feed livestock, sell or use as fuel-wood. Farmers with livestock take their animals to their farms for grazing, thus eating the remains of plants that protect topsoil from wind and water erosion.

Deforestation: The process of cutting down trees has been practised for decades in many parts of Yobe State. During the FGD, farmers highlighted that they cut trees to cater for some of their daily needs due to drought-shock. They recognised that if there were alternative sources of income they will not practise deforestation. They commented that government officials had been warning them of the consequences of their actions. Some farmers

highlighted that ~30-40 years ago, there was a very thick forest in the area, where anything ~200 m within the forest could not be seen from outside, presently there is no vegetation cover.

One problem farmers confirmed numerous times is the issue of desert encroachment on their farms. Communities find it difficult to adapt to these environmentally-stressed conditions in a sustainable way (drought-shock), environmental consciousness will always be an issue if poverty and drought impacts remain unmitigated in those areas. Finding the balance between their survival and prioritising the environment by farmers that rely on harvests is difficult. During the FGD, farmers stated that sand often covered their farms after a year of harvests. This also contributes to low soil fertility, thus resulting in poor yields. F6 commented *"we have no any other option, but to still plant our crops on the same land and we also expect much from it afterwards, this is a situation we understand we have been contributing to and is affecting us. We believe measures can be taken to assist and rescue us from this situation".* Plate 5.2 shows farmers during the community FGD and the researcher explaining the importance of the session. These are common practices among African farmers, as they receive limited or no support (FME, 2012; Shirafew *et al.*, 2014 and Nwokocha, 2016). Drought coping strategies stated by farmers also proved that Objective 3 of Aim 2 should be addressed in order to build resilient environments for drought victims.

5.4. Farmers responses to drought mitigation

Farmers have different strategies for coping with drought. Many farmers commented during the FGD that they usually pray to God (Allah) for rainfall. This has been practised in the religion of Islam for many years. Most farmers believed this is the only thing they can do if drought persists. Farmers said they have nothing else to do apart from wait for God's intervention (Plate 5.2).

Plate 5.2: Focus Group Discussion with farmers at Karasuwa Local Government Area researcher's photo (01/10/2016).

This is similar to the situation in Iran, where farmers pray and mostly do nothing during drought (Dariush *et al*., 2010). Social response was initiated in the preliminary conceptual framework of this research, to advocate strategies where communities can respond to drought by themselves before any external support or intervention. Many farmers have no option during droughts, especially extreme episodes, when their crops are damaged and livestock are dead. However, this shock can cause mental health problems and other illnesses among drought victims. They were also asked if traditionally within the community they do something in response to drought. In this regard, farmers had different views where some commented that they are helpless, as they cannot support each other, since they are all affected. According to F9 "*it is very difficult for us to ask someone for help when he also needs help, this is how we mostly live when drought occurs and in recent years, we have seen how this disaster had cost us a lot in our community."* Some farmers said that they migrate to

places where they can seek casual jobs, in order to sustain themselves for a while before they return for the rainy season.

Most farmers migrate alone, leaving their families behind. In rare cases if they were able to secure a comfortable environment or job, they move their families to their new places. There are many challenges attached to migration. Drought victims are at risk of falling into dangerous situations, as many of them do not know where they are going. Before the emergence of insurgents in North-East Nigeria, some farmers migrated to places bordering Cameroon and the Chad Republic, in the Lake Chad River Basin, for irrigation and fishing.

However, insecurity in the region has played a key role in restricting transhumance and farmers' migration. They can move freely to any part of the country, as everyone is allowed to live where they want. There are many Nigerians that live in different regions than their origin. On the other hand, some farmers resort to cutting down trees on their farms or grasslands near their community. Some people travel many kilometres (20-30 km) in search of trees to cut. According to F13 *"if we are empowered or assisted in any way we will not practise such acts of cutting trees."*

5.4.1. Farmers suggestions on drought mitigation

Farmers' views on how they think impacts of drought can be reduced in Yobe State were sought during the FGD. These are some of the measures used to develop drought mitigation frameworks.

Social amenities and welfare: Discussants in the session raised the importance of having access to clean water, good health care systems, road and modern farming machinery. They stated that after drought or harvest losses they cannot afford to pay for hospital treatments.

As some hospitals are distant away from their communities, it is difficult to get there due to poor roads. If proper farming tools are provided to them it will enhance their farming capacity, which they believe will improve crop yields.

Fertilizer supply: Many farmers agreed that if fertilizers (inorganic) are provided consistently or sold at subsidised rates during the rainy season for their crops, this can assist in mitigating drought impacts. Most crops wilt during growth; but fertilizer application will help in rapid crop growth. If fertilizers are supplied and crops are in good condition, livestock fodder can also be obtained after the rainy season Denning *et al*. (2009).

Improved seed supply: Farmers stressed the need to have improved varieties of drought-resistant crops seeds. However, most local seeds are not drought resistant. It usually takes many days for crops to germinate and mature for harvest. Insufficient rainfall further exacerbates the problem.

Irrigation farming: Irrigation farming is unusual in the area. The questionnaire survey showed that most farmers' practise rain-fed farming in Yobe State. As part of their suggestions, farmers stressed the need for them to have access to irrigation water. However, water availability is a major limiting factor. In recent years, agriculture has been the major consumer of fresh-water. Over the past ~50 years, environmental and human water demands have remarkably increased. Most farmers suggested that boreholes should be provided for irrigation. Despite the difficulties they face due to drought, they are still committed to irrigation farming systems. If proper irrigation programmes are established, farmers will participate.

Pest control: Due to variable rainfall, farmers are faced with pest invasions. Farmers stated that whenever there is low rainfall, pests (insects) invade their farms and destroy crops. However, they noticed that if there is average rainfall, they face fewer pest invasions. The

problem of pest invasion was not mentioned the questionnaire survey, but the issue was raised during the FGD. Insect pests in Nigeria cause ~25-30% crop losses to small farmers (Tobih, 2011). If this is also controlled, it can reduce the cost of crop losses. Some crops damaged by pests also have adverse effects on their animals. In some cases, if their livestock feed on the crop leaves and stems infected by the pest, it kills them. Farmers stated that they can manage to traditionally control bird invasions, but it is difficult for them to control insect pests.

Miski (loan): This is a local method where farmers borrow grains or cash from friends and family. The loan is to be paid back after farm harvests, but no interest would be paid. This method was practised before, but is no longer in use.

Katifu (aid): This is also practised locally by farmers. This is the process of storing excess farm harvest for future use. It is rarely practised now, as most farmers do not have sufficient crop yields.

5.5. FGD session with the Ministry of Environment Officials

The FGD session took place at the Ministry of Environment complex, with four Deputy Directors and one Environment Officer on 05/10/2016. Presentation of the previous questionnaire survey results provided Ministry officials with insights on the research programme. Table 5.1 shows experience and designations of the FGD participants from the Ministry of Environment of Yobe State. Participants have sufficient and varied experience and knowledge of drought in Yobe State, with over 110 years of combined relevant experience (Plate 5.3).

Table 5.1: Working experience and designations of Ministry of Environment officials

S/no.	Designations	Departments/units	Years of experience
1	Deputy Director (D1)	Drought and Desertification Control	25 years
2	Deputy Director (D2)	Forestry Parks and Gardens	24 years
3	Deputy Director (D3)	Forestry and Wildlife	30 years
4	Deputy Director (D4)	Alternative Energy	22 years
5	Environmental Officer I (D5)	Environmental Protection	4 years
6	Environmental Officer I (D6)	Environmental Protection	5 years

Plate 5.3: Deputy Directors from the Ministry of Environment of Yobe State with the researcher

5.5.1. Problems of drought in Yobe State

According to the Ministry of Environment officials, drought mitigation has received insufficient attention. Rainfall distribution varies in different parts of the State according to the discussants, some areas receive sufficient rainfall, but not throughout the season. Yobe State rainfall data from NiMET (2016) further shows the rainfall distribution in the State (Section 1.4.3). According to D1 *"the problems over the years have caused livestock mortality, starvation, diseases, shock to businesses and threats to the environment."* Due to drought impacts in 2009, the State Government constituted a Committee to assess how drought has affected people. The Committee submitted their Report to the Government, where the State Government received relief materials for victims from the Federal

Government (FG) through the 'National Emergency Management Agency' (NEMA). Based on the Committee's recommendations, the State Government requested more intervention from the FG. However, the items received were insufficient after distribution. Other affected individuals and areas in the State have not received any assistance.

The assessment by the Committee was conducted by meeting with village heads and traditional leaders. According to the survey results reported in Chapter 4, most farmers had not received any relief from either government or NGOs. However, this can be due to the quantity of materials supplied and number of affected people. They stated that drought is affecting livestock and cash crop markets in the State and this also reduces food supply and revenue for the State Government. Many farmers have lost their livestock due to drought, due to livestock malnourishment thus reducing their market value. Low farm outputs, lack of animal feed and increasing food prices in the State remains. Thus many farmers are unable to produce sufficient food from their farms for both personal and commercial purposes. Plate 5.4 shows the researcher and Directors shortly after the FGD session in the Ministry of Environment Yobe State complex Damaturu, on 05/10/2016.

5.5.2. How policy can mitigate impacts of drought in Yobe State

A drought policy is a set of principles that establishes clear guidelines of drought management. It is important that drought policy emphasises the paradigms of preparedness and mitigation. According to the discussants, if a drought policy is drafted and properly implemented, it will help mitigate the effects of drought on both citizens and the environment. The implementation will ensure that before, during and after drought, measures can be taken to reduce the effects. Discussants explained the processes of how they draft and implement policy at State level. For government to have such policy, areas of intervention must be mapped out, then policy can be deliberated and drafted by the Ministry.

Plate 5.4: Focus Group Discussion at the Ministry of Environment (05/10/2016).

All matters discussed are forwarded to the State Executive Council (EXCO), of which the Commissioner of Environment is a member. The policy approved by the Council is then forwarded to the State Assembly (Parliament) for it to pass as legislation and assented into law by the Chief Executive (Governor) of the State. Figure 5.1 is a flowchart drawn based on how the discussants explained the process of drought policy implementation in Yobe State. The discussants stated that if all these actions and plans are properly implemented by the State, drought effects will be drastically reduced. However, effects will reduce only if the measures considered in the policy are both risk management and crisis management driven.

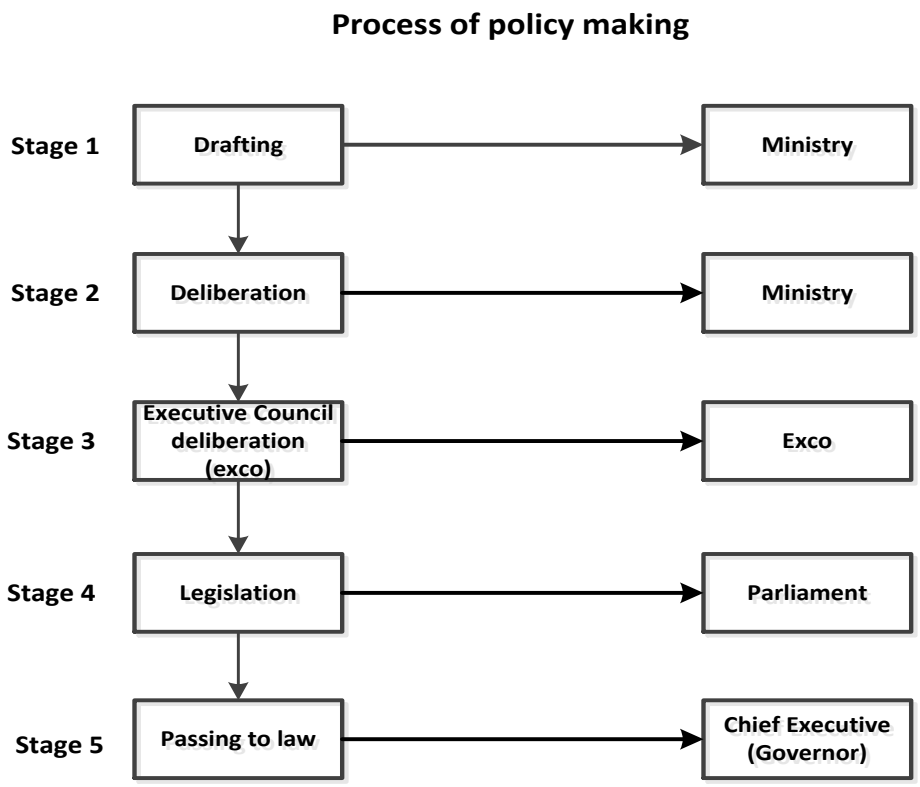

Figure 5.1: Flowchart of drought policy implementation in Yobe State.

All Ministry participants were of the same view on how drought policy can help reduce the impacts through government actions. D1 advised that there is a 'National Drought and Desertification Policy,' but it was rarely implemented. Yobe State has no drought policy in place for the government to follow. Every drought situation is different adapting a national policy is difficult. They stated that having a state drought mitigation and management plan based on drought problems will be more suitable. D2 stated that "*designing or initiating a policy is something, but implementing it is another thing."* They also discussed that if the framework proposed by this research is tested and proved successful, it can be transformed to a programme and incorporated into short, medium and long-term programmes. Discussants stated that drought mitigation needs a multi-faceted approach and shift from conventional strategy to risk management.

5.5.3. Challenges of implementing a drought policy in Yobe State

During the FGD, the officials stated that one of the major challenges of implementing a drought policy in Yobe State is "*bureaucratic inertia."* This is the delay caused by bureaucratic processes in government, where the draft passes the first stage, but passing the second and third stage can be problematic. If there is smooth process in the system, the problem of initiation and implementation will not be an issue. Another challenge is that State legislators delay actions before legislation can be approved by Parliament. However, these challenges are not just for drought policy implementation, but apply to many government initiatives, according to the discussants. Costs of implementing policy strategies can also hinder policy implementation, because of insufficient funds. However, there is an ecological fund meant to address such issue (FGN, 2005). The discussants did not clarify during the session if such funds were received by the State and utilised in drought mitigation.

5.5.4. Paradigm shift as measure of drought mitigation

The need for new approaches and a paradigm shift from reactive (crisis) management to proactive (risk) management of drought impact mitigation was stressed by officials. The same (reactive) method was used in 2009 for drought relief material distribution, where many farmers and victims were not assisted. Thus there is a need to assess which part of the State was more vulnerable to drought. According to the results from the cross-tabulation presented in Chapter 4, the most vulnerable part of the State is Yobe north. There is the need for early assessment to evaluate which areas of the State need particular attention, since all affected parts cannot be considered for action simultaneously. The importance of assessing the most vulnerable areas is to provide support and early action, so that many victims and the environment affected would receive the necessary timely intervention.

Discussants were asked if any proactive measures were set up by the State government during recurrent droughts. They stated that there is no proper and comprehensive proactive measures

were in place to mitigate drought. For example, the State has only two conventional weather stations (Potiskum and Nguru), which is insufficient to efficiently monitor drought. They stated that if new technologies and expertise were available it will help proper monitoring of drought trends, as in technologies to monitor drought across the US (NDMC, 2016). They discussants further stated that the process of using technology, involving stakeholders and Early Warning Systems are not in place in Yobe State. Thus, is difficult to communicate accurate information to farmers and communities before or during droughts. Discussants believed that having such systems and processes will improve drought mitigation and management in Yobe State.

5.5.5. Environmental threats due to drought

Result from Chapter 4 showed that people have different strategies to cope with drought in the State. This has enormous environmental impacts, where the level of water has reduced, vegetation cover is least and desert encroachment is increasing. Officials from the Ministry of Environment stated that their monitoring teams had all reported increases in all environmentally-unfriendly activities. In recent years, there have been no measures taken by the State Government to curtail these or any NGO advocating mitigation of environmental degradation. These activities include unlawful felling of trees, degrading marginal lands, poaching wild animals and bush burning. Such acts have devastating effects on the environment and their inhabitants (Olagunju, 2015).

Renewed efforts by government and civil leaders are essential to help reduce environmental degradation in the State. Previously, the Ministry of Environment initiated efforts to address reckless environmental activities, but momentum has decreased. Proper monitoring and renewed law enforcement will assist in reducing human environmental impacts. In order to have quality environments, leaders have to change from being relaxed and considering environmental responsibility to be solely the domain of environmental activists.

5.5.6. Measures for drought mitigation by both sessions

According to Ministry of Environment officials, if some of these measures are initiated, it will reduce the impact of drought in the State. Potential methods include:

Irrigation: Farmers were asked if irrigation could mitigate the effects of drought. During the FGD session, all 19 farmers were of the same view, that irrigation would create employment and engage most farmers throughout the year, rather than just waiting for the rainy season. All six Ministry of Environment officials shared the same opinion that irrigation will mitigate drought. The practise would increase food production, create employment, reduce deforestation, decrease soil erosion and generate income for government via taxation. Certainly, there are challenges before initiating irrigation, for example, water catchment, infrastructure, expertise and proper practises must be in place.

Tree plantation (afforestation and reforestation): Farmers and government officials agreed that deforestation has increased in recent years. Officials stated that tree planting will assist in reducing desertification, which accords with the report of FME (2012). Afforestation programmes should be enhanced and modern technology can be used to improve the practise. Similarly, they stated that providing grazing reserves and woodlots would reduce over-grazing and exploitation of forests. According to D3, there is a FG programme to create shelter-belts and tree plantations to decrease desert encroachment. The shelter-belt project will cover ~1000 km across the northern border with the Niger Republic; covering seven northern States of Nigeria (Sokoto, Zamfara, Kano, Katsina, Jigawa, Borno and Yobe) (Section 2.12.2).

Places with previous vegetation, before should be restored through reforestation. The discussants stated that the ‘Great Green Wall for the Sahara and Sahel Initiative’ (GGWSSI) project execution has been very slow, due to government funds.

Awareness for community members: Creating awareness was raised during the FGD as a crucial component of drought mitigation strategies. Most farmers know drought very well, but their activities increase drought severity and intensity. Mobilising communities across the State can help reduce the impacts of drought. However, there is no programme in place in the State to create awareness of drought amongst communities. Other studies have stressed the importance of awareness in drought mitigation (Olagunju 2015; Nwokocha 2017).

Pest control: As stated by both farmers and officials, pests are problem during droughts. According to Officials, pest control is crucial, as if not addressed the impacts of drought will further increase, as the remains of farmers' crops and livestock can be completely destroyed by insect pests. They also stated that there is a need to use suitable approaches and seek expert advice on pest control.

Supply of improved seeds: Supply of improved drought-resistant crops seeds can reduce the effects of drought. Participants expressed their views that this can be achieved through research using experts. This proposal was welcomed by most farmers during their FGD session.

5.6. Summary

Two FGDs were conducted at the community and Ministry level. Participants were selected using key informants at the community level. At the community level, 19 willing farmers participated in the session. Farmers expressed their views that rainfall is their main problem, as they all depend on rain for their harvests and livestock feed. The rainy season in Yobe State is highly. In some communities farmers sow their seeds one or two months before the proper rainy season establishes, in fear that they will not have sufficient rainfall for their crop to germinate and grow for full harvest. Others are of the view that, for the past 12 years, they have not had a 'bumper' harvest. The major issue is that when the rainy season starts in most

parts of the State, it ceases when plants need water for growth, thus wilting plants. The process of early sowing at first rain of the season is locally called '*Kiri*.' Farmers agreed that they contribute to environmental degradation. Inappropriate activities include bush-burning, over-harvesting, over-grazing and deforestation. A problem the farmers confirmed numerous times is desert encroachment. Proper awareness, social safety nets, monitoring and enforcement will reduce drought and desertification problems.

According to the Ministry of the Environment officials, drought mitigation has not received due attention. According to discussants, if a drought policy is drafted and properly implemented, it will help mitigate the effects of drought on citizens and the environment. During the FGD with officials stated that the major challenge of implementing a drought policy in Yobe State is "*bureaucratic inertia.*" Staff training to improve and increase service efficiency is imperative. Chapter 6 is the discussion of some major findings from this research.

CHAPTER SIX DISCUSSION OF FINDINGS

6.1. Introduction

Following the analysis of the results in Chapters 4 and 5, this chapter discusses the outcomes of the analysis. The chapter presents answers to the posed research questions.

6.2. Assessment of drought mitigation policies in Nigeria

To investigate efforts made in Yobe State, officials from the Ministry of Environment were interviewed during the FGD. Based on the officials' statements Yobe State Government is not doing sufficient to mitigate impacts of drought in the State. This is because Yobe like most State governments in Nigeria, do not take drought mitigation and management very seriously (Oladipo, 1993). The literature has not identified any state in Nigeria that has a proper drought mitigation strategy. The Nigerian Government has introduced and implemented some drought mitigation policies and strategies (Section 2.12.2). FAO (2018) reported that stakeholders and local communities were involved in process of drought mitigation in Kenya, whereas studies from Nigeria for example, FGN (2005) and FME (2012) have not stated whether communities' representatives were involved in the process of designing mitigation policies and strategies.

Following the explanation provided by the officials on how drought policy can be implemented in Yobe (Section 5.5.2, figure 5.1), there has been no evidence reported where farmers and communities were involved in the process of designing policy or mitigation measures. One of the reasons some policies/strategies fail is due to the negligence and mismanagement of projects by beneficiaries (Nwokocha, 2016). Results from survey and FGD showed that farmers have never been involved in the Federal Government's awareness programme or received interventions. However, farmers from Gursulu village in Yunusari LGA had been involved in a desertification awareness programme (Gbahabo, 2011).

Officials identified funding as one of the challenges that affects drought mitigation policy implementation in Yobe State. Funding being a challenge has also been identified by other levels of government in the country (Section 2.12.2). The current study argues that bottom-up approach is vital for drought mitigation and this will commit farmers to the cause. Amongst the 10 step of drought policy implementation process suggested by Wilhite, (2016) step 8 is relevant to involving local farmers. Step 8 stated that awareness and drought mitigation plans should be publicised and people should be involved at all levels throughout the process.

During the FGD with the Ministry of Environment officials, it was evident that the discussants want drought mitigation to be treated as multi-faceted issue cutting across different sectors. Treating drought mitigation as a multi-sectoral approach is challenging, because each sector's role has not been clearly defined (FME, 2012). It is also better for government to bring all stakeholders (expertise from various agencies, policy-makers, decision makers and community representatives) required for the process under one platform and implement policies/strategies. This option is preferred to engaging a whole department or unit from different ministries or agencies, as the approach involving whole departments will increase implementation costs. If experts are brought together from various agencies the process will be more cost effective and at the same time involving relevant sectors.

6.2.1. Nigeria Drought Policy (National Drought and Desertification Policy, 2007)

Officials from the Ministry of Environment of Yobe State discussed a drought policy document developed by the Federal Ministry of Environment. The policy document reviewed addresses impacts of human activities on the environment. Strategies such as awareness, grazing reserves, poverty reduction, land use management, afforestation and alternative energy were the major actions suggested by the National Drought and Desertification Policy NDDP (2007). The policy mainly focused on environmental aspects of drought, with little emphasis on addressing socio-economic problems causing environmental degradation

(Msangi, 2004). The proposed frameworks from this research established strategies to tackle socio-economic effects of drought, which exacerbates environmental problems highlighted by the NDDP (2007). However, some of the strategies highlighted in the policy related to poverty, alternative energy and awareness are measures that can be used to address social problems caused by drought. Table 6.1 highlights some strategies adopted by the NDDP (2007) and those proposed by this research.

Table 6.1: Review of drought mitigation measures of National Drought and Desertification Policy

S/no.	NDDP's highlighted effects of Drought	NDDP's proposed mitigation measures
1.	Populations, poverty, land use and soil conservation, energy, and depletion of water resources.	Crop production, livestock rangeland and grazing reserves, afforestation and woodlot, water management and law enforcement.
	This research's effects of Drought	**Proposed mitigation measures**
1	Social impacts: Migration, unemployment, poverty, and recreation.	Community response and structure, awareness and education, social infrastructure and amenities.
2	Economic impacts: income loss, harvest loss, increased food prices, livestock mortality.	Sustainable irrigation practises, fertiliser supply, establishing food reserves, loan/insurance, grazing reserves, supply improved seeds and access to markets.
3	Environmental impacts: deforestation, soil degradation, over-cultivation, desertification, reduced biodiversity, and bio-productivity.	Afforestation and reforestation, crop rotation, conservation of water resources, woodlot establishment, reduce hunting, land use management.

The NDDP (2007) has not considered proactive drought mitigation and management. For instance, irrigation recommended by findings from this research and literature through sustainable irrigation practice was not highlighted in the NDDP (2007) policy document. As a consequence, this research recommends a review of National Drought Desertification Policy (2007) to suit current drought conditions.

6.3. Impacts of drought in Yobe State

Results from the questionnaire survey showed that drought has affected many farmers in Yobe State. Most farmers practise rain-fed farming, which is the norm in the Sahel region (Cooper *et al.*, 2008). This is as a result of low rainfall, increased temperatures and

evaporation (Shiru *et al*., 2018). Finding from the survey of this research correlates with Shiferaw *et al*. (2014) and Wossen *et al*. (2017) which stated that farmers are vulnerable to drought impacts in Sahel and in northern Nigeria (Abdullahi *et al*., 2006; Olagunju, 2015). Most farmers have lost ~70-80% of their harvests, and most respondents are unemployed, with no alternative source(s) of income (Wossen *et al*., 2017). Financial support for farmers in Australia has helped in mitigating drought impacts (White *et al.*, 2005). It would be helpful if Yobe State farmers can be supported in the same way as their Australian counterpart. According to the analysis conducted in (Section 4.3) it was surprising to note that Machina receives some of the lowest rainfall in both 2008 and 2009, but it showed that crop production is significantly high in the location. This statistics show that there is a probability that harvest loss in the study area can be influenced by both rainfall and other environmental variables. It is beyond the scope of this research to investigate what other variables might have influenced harvest loss and high yields in other areas in the State. Result from the survey showed that farmers believed there is increase in food prices during and after drought, Gbahabo (2011), reported that there is increase in food prices, due to harvest loss based on participants from Yunusafari LGA. This increases stress to farmers after difficult harvest season, it is therefore important for farmers to be more self-reliant and have alternative income sources.

Cross tabulation (Chapter 4) shows that Yobe North is more prone to drought due to reduced rainfall and harvests losses in the region. However, understanding spatial patterns of drought will help pre-disaster preparation and recovery. This will also reduce intervention costs as all required needs have been identified based on drought severity. During drought preparedness, mapping out areas and prioritising need is crucial (Wilhite *et al*., 2000). It is also surprising that farmers from the three regions of Yobe State use different coping strategies, which may be due to different socio-economic situations across the State. Farmers strongly disagreed

that livestock sales compensate for drought shock. Similarly, Shiferaw *et al*. (2014) and Wosson *et al*. (2017) reported that selling livestock does not reduce shock, as most livestock values fall due to malnourishment. Farmers complained about insect pest invasion, which affects their harvest and livestock. Due to the level of harvest loss, it is important that improved seeds (crops) are provided to farmers, as this was also noted by Abubakar and Yamusa (2013) that improved and certified seeds can help reduce severe harvest losses. Social response by farmers is important in dealing with drought impacts. In the farmers' FGD session, it was reported that decades ago people used to give out loans of grains, animals and other capital to their community and family members during drought. The loans were returned without any interest, the same amount of capital or quantities of grain collected are paid back. However, this is now not practised following losses caused by recent droughts. Traditional techniques such as '*katifu* (aid) and *miski*' (loan) are recommended. Farmers find it difficult to give loans after the rainy season due to recurrent drought and soil infertility (Shiru *et al*., 2018).

6.4. Mitigation measures and paradigm shift

Farmers strongly agreed and further emphasised during the FGD session, that access to good health care, irrigation, good roads and clean water would reduce drought shock. Improved social welfare and infrastructure also reduces drought shock (Eludoyin *et al*., 2017). Farmers stated that these supports mechanism are absent. The survey also showed that most farmers have not received relief or any support during and after droughts. This shows the need for a shift in drought mitigation approach. Officials from the Ministry of Environment stated that reactive measure had proved costly to Yobe State Government after the 2009 drought event. Generally, reactive measures cost more after the events than developing proactive measures (Wilhite, 2005).

If reactive measures are used it takes time for communities to recover. This is where Early Warning Systems and planning play vital roles. FGN (2005) stated that they will improve Early Warning Systems by providing necessary data to states on drought occurrence, but the officials from the Ministry of Environment stated that no progress has been made. Hence, the proposed Integrated Framework has both reactive and proactive measures. Occasionally, on one or two occasions, reactive measures of drought assistance (relief) were provided. These have proved unproductive and unsuccessful, as this method was challenged by drought intensity in recent times (Wilhite, 2005, 2016).

Despite proactive measures being better, the Nigerian Government efforts on drought mitigation has focussed on reactive measures. Good role models include Central and Eastern Europe (CEE), Mexico and Spain. They have introduced frameworks that promote sharing knowledge with stakeholders in their drought management policy (Sections 2.9.1, 2.9.2 and 2.9.3). Based on the findings from FGD with the Ministry of the Environment officials, these processes are non-existent in Yobe State. This research has established that a paradigm shift and change in approach is necessary in order to manage drought. It is proposed that improved adaptive drought strategies will decrease vulnerability of farmers in Yobe State. It is paramount that mitigating drought impacts should be holistic in order to reduce the severity of future events. Population growth and dependency on fragile dryland environments increase the risks of severe droughts (Wilhite, 2005; Pravalie, 2016), hence, the need for collective drought mitigation strategies.

Drought monitoring using advanced technology is used in many places with frequent droughts (Sections 2.11 and 2.11.1). Satellite images are used to translate climate variables for proper preparedness and Early Warning communication. These systems are needed in Yobe State and discussants from the Ministry of Environment have stated that if such technologies are available it will improve proactive measures of drought mitigation in the

State. Yobe State is doing little in terms of improving drought mitigation and shifting paradigms and processes to adopt such measures. This research argues that a paradigm shift in drought mitigation is necessary in Nigeria, as it incorporates measures that make communities and farmers more self-reliant. The process identifies areas of need before droughts, which improves drought mitigation plans.

6.5. Irrigation as a mitigation measure

Farmers in the FGD believed rainfall scarcity is their main problem (Section 5.2). During the FGDs, both sessions agreed that irrigation is an important measure to mitigate the impacts of drought and accords with Abubakar and Yamusa (2013) and Eludiyon *et al*. (2018). Irrigation in dryland increases soil salinity (Rietz and Hayens, 2003). Large-scale irrigation in drought prone areas is expensive and previous projects in northern Nigeria have failed (ODI, 1987). Thus, it is important that appropriate and low risk irrigation approaches be applied in the study area. ODI (1987) did not specify if feasibility studies were conducted to ascertain the risks and adverse impacts of irrigation prior to commencement of the projects.

If Yobe State opts for irrigation as a mitigation measure, then feasibility studies should be conducted (analyse soil fertility and salinity risks). If such measures are not employed, there is the possibility of increasing land degradation. Irrigation requires accessible water for it to succeed and the hydrogeology of the State has shown the potential to irrigate using ground-water (Dawoud and AbdelRaouf, 2002; Musa, 2011) (Section 2.6.2).

6.6. Environmental problems and management

Some farmers reduce the sizes of their farms, whereas others increase the sizes of their farms during drought in Yobe State. The review of relevant literature indicated no study had reported similar practices. If farmers are allowed to expand their land uncontrollably, environmental degradation will increase (Gbahabo, 2011). Farmers from southern Nigeria

stated that they change their planting times and crops to reduce losses (Ayanlade *et al*., 2018). Results from this research showed that farmers need to be trained to adopt similar practise to help reduce losses. It is evident that farmers are trying to obtain maximum yields on their farms. Over-cultivation and over-grazing are common practices among Sahelian farmers (Shiferaw *et al*., 2014) and in Nigeria (Abdullahi *et al*., 2006; Olagunju, 2015). Environmental degradation practises in the study area include bush burning, over-harvest and grazing, deforestation and wildlife hunting, which accords with Agnew and Warren (1996), FAO (2010), Reynolds (2016). During the FGD farmers discussed the consequences of such practises, but were not shown other techniques that could be used to manage their farms. Studies have shown that proper land management reduces drought impacts and increases soil fertility (Msangi, 2004; FAO, 2018). This type of practise was reported by (FAO, 2018), but was not reported by farmers in Yobe State and at the same time other studies conducted in Nigeria (Section 2.5.5.2).

Farmers recognised that desertification has increased due to their activities. Similarly, Musa and Shaib (2010) reported increase in vegetation loss using remote sensing technology. This is also attributed to the fact that farmers believed that poverty causes damage to the natural environment after drought impacts (Table 4.25). Farmers believe they can be assisted by the government to reduce drought impacts and desertification. Lack of support and help from NGOs to affected communities in drought and desertification prone areas in Yobe is a major problem. The Nigerian Government is committed to invest in the Great Green Wall for the Sahara and Sahel Initiative (GGWSSI) Project to decrease desertification (FME, 2012). In the FGD the Ministry of Environment officials stated that the problem of environmental degradation can be reduced through proper education, legislation and law enforcement.

6.7. Answering research questions

Research question 1: ***How does drought affect livelihood of farmers in Yobe State*****?**

The study answered this research question in Chapters 4 and 5. Farmers' livelihoods have been severely affected by drought in Yobe following poor harvest and livestock mortality. Details and level of impacts have been reported in Chapters 4 and 5.

Research question 2: ***How does drought coping strategy affect the environment in Yobe State?***

Drought coping strategies by farmers in Yobe State have increased desertification and environmental degradation. Farmers' practises include bush burning, over-grazing, deforestation, hunting and over-cultivation (Chapter 5). Such practices decrease soil fertility and the degradation of marginal lands (Agnew and Warren, 1996; FAO, 2010; Reynolds, 2016).

Research question 3: ***Which parts of the State are most vulnerable to drought*****?**

In order to provide information that could assist framework users map and design timely intervention, it is important to investigate parts of the State vulnerable to drought and Yobe North is most vulnerable to droughts.

Research question 4: ***What are the possible ways to mitigate drought effects at local levels before intervention or support?***

Considering traditional methods of drought mitigation at community level before intervention, farmers stated they had traditional methods (Misk and 'Katifu), but it was difficult for them to practice due to the levels of losses after recent droughts. The framework from this research should include strategies that will make farmers more self-reliant.

Research question 5: ***What are governments' efforts and how can they be improved?***

Critical evaluation of efforts was conducted in Chapter 2. This established that approaches need to be improved. Chapters 4 and 5 collated farmers' views of what will assist in reducing the impacts of drought. All the research questions posed in section 1.5 thus findings were used to develop frameworks drought mitigation and management in Yobe State (Chapter 7).

6.8. Summary

This chapter has discussed the major findings from this research and stressed the importance of drought mitigation in Yobe State. Farmers need more support to reduce drought shock, which accords with similar research studies conducted in other places. Specific issues include pest invasion and farm management.

CHAPTER SEVEN: DROUGHT MITIGATION FRAMEWORK DEVELOPMENT AND EVALUATION

7.1. Introduction

To achieve Aim 2 of this research, and Objectives 1 and 2, this chapter presents the development and evaluation of three frameworks for drought mitigation and management. Based on the literature reviewed a preliminary conceptual framework was developed, which was used for the empirical studies and help develop the sectoral and integrated framework. The three sector drought mitigation frameworks developed include: social, economic and environmental frameworks. An Integrated Framework of drought management strategies was also developed based on the three sector frameworks. Before-use framework evaluation was also conducted to assess the robustness and applicability of the framework through respondent validation.

7.2. Preliminary conceptual framework

Development of a preliminary conceptual framework forms an integral part of research. It also serves as basis for analysis of interrelationships between concepts (Huberman and Miles, 1994). This type of framework is mostly derived from the literature of a study and theoretical understanding in order to translate it into practise. Preliminary conceptual frameworks collate key factors, variables and concepts and their presumed relationships (Huberman and Miles, 1994). Information from the literature, gaps identified and details on drought impacts in Nigeria (Section 2.13) prompted the design of the preliminary conceptual framework to guide the study in achieving its aims and objectives. The preliminary conceptual framework informed the process of data collection for the assessment of drought effects in Yobe State. The purpose is to develop a workable framework that will aid the amelioration of drought in Yobe State. The preliminary conceptual framework was designed in three different components, with each having either direct or indirect relationships amongst the variables.

The components include *effects*, *input* and *output*. The preliminary conceptual framework highlights how measures would be taken to mitigate the effects of drought.

Effects: These consist of the social, economic and environmental effects.

Inputs: These are expected strategies/measures to mitigate the effects of drought on socio-economic activities and the environment. It is expected that in this process victims, communities and government will co-operate.

Challenges: These are the hurdles expected before policy can be implemented. This research investigated and recommended solutions.

Output: This is the final output of the framework, i.e. what the framework is expected to achieve after full consideration and implementation.

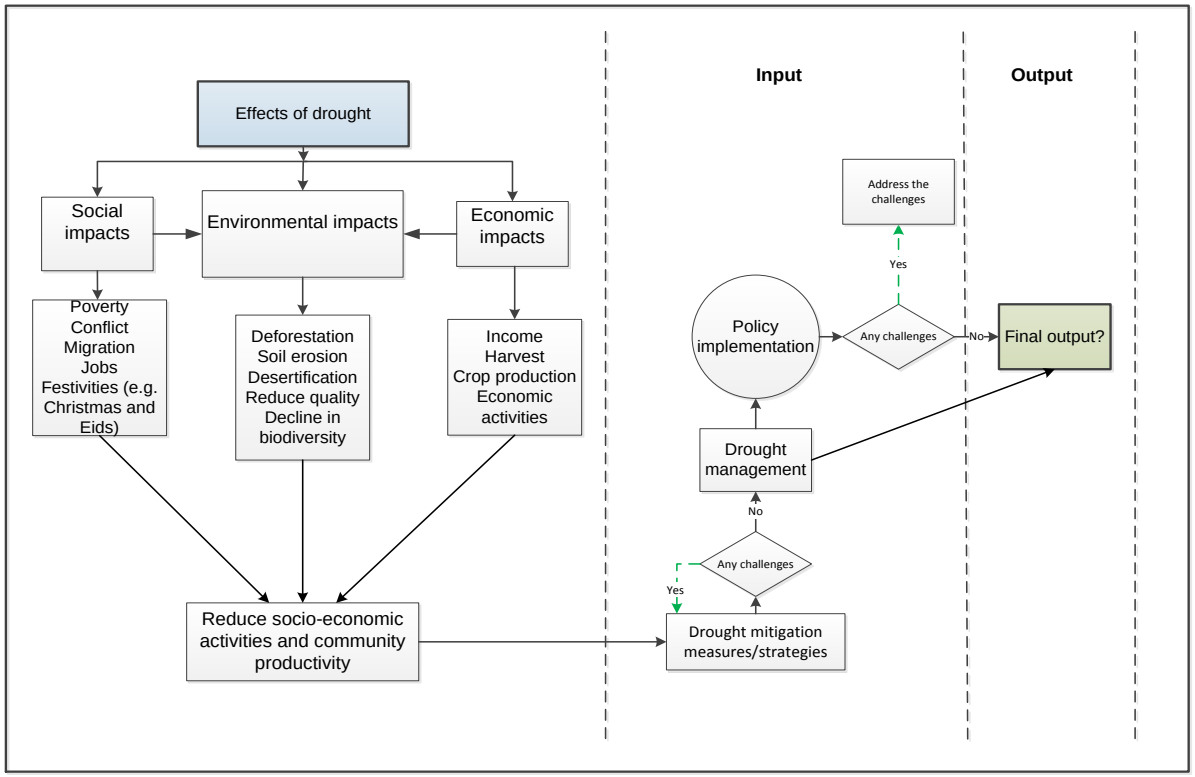

Figure 7.1: Preliminary conceptual framework.

7.3. Framework development

To develop a robust and clear framework, components of the preliminary conceptual framework social, economic and environmental were used (Figure 7.1). The sector frameworks were combined in a final framework ‘’Integrated Framework’. Both proactive (risk) and reactive (crisis) measures of drought mitigation were included in all frameworks. Possible mitigation and management strategies suggested by farmers, Ministry of the Environment officials and the literature were considered in the development of the framework. These strategies/measures would help provide alternative to stakeholders (farmers, communities, government and NGOs).

This research chose a ‘bottom-top’ approach, where farmers’ suggestions were given priority. Stakeholders can choose to use the framework that will address their needs. For instance, any community, NGO and government can adopt any of the social, economic or environmental frameworks depending on their need. Preferably, all frameworks should be implemented. It is important that stakeholders should be responsible for drought mitigation and management, during and after implementation. However, in order to holistically approach drought mitigation and management, the final Integrated Framework is more suitable for implementation, as it combines management strategies for long-term mitigation. It is expected that government(s) should evaluate and then adopt the Integrated Framework.

7.4. Drought mitigation frameworks

These are measures/strategies taken to curtail the impacts of drought across Yobe State. All effects highlighted in the different sectors are expected to be mitigated using the measures or actions employed in this section. The impacts have been highlighted in the preliminary conceptual framework (Figure 7.1).

7.4.1. Social Impacts Drought Mitigation Framework

These are possible measures to mitigate social effects of drought in Yobe State.

Awareness and education: Effective community and societal based awareness is important for drought mitigation. Most farmers know what drought is, and understanding it is very important to help reduce its effects. Educating farmers and people on how to prepare and manage drought before, during and after the crisis is crucial. Lack of clear consistent information affects drought mitigation (Buchanan-Smith, 2000). Awareness of when and where drought impacts will be more pronounced should be communicated to farmers and communities. Farmers should understand plantation and harvest period which is important for crop production during drought (Bodner *et al*., 2015). Timely advice of types of crops to be used during a predicted episode should be communicated to farmers on time. As it will be difficult for some farmers to understand the cultivation process of the suggested crop, because most of them only stick to what they traditionally know. It is important involve stakeholders at all levels in the process if climate change adaptation and drought mitigation (Aakre *et al*., 2010).

Community response and structure: Farmers emphasised on community based support systems as a means to respond to drought (Table 4.39). Communities have responsibility to take actions to mitigate the impacts of drought. A community establishment should be created by community members, as a proactive strategy to support drought victims through a chain of leadership within communities. Willing community members should register a co-operative or association that will give them a platform, and provide opportunities for easy identification and serve as channels of intervention. The association can be tasked with collecting stipends from members during 'bumper harvests' to serve as insurance. These stipends can be given either in cash or kind, before or after drought. All cash crops contributed can be sold at lower rates to members during and after drought. Associations can venture into business with the

capital or collateral provided to increase profitability, low risk businesses are suggested. Communities will be more viable and self-reliant if such structures are in place. This is also similar to a project introduced by the World Food Programme in Kenya. Farmers were asked to establish such an association to serve as a platform for invention and other drought mitigation programmes to improve their self-reliance (WFP, 2018).

Social infrastructure and amenities: Most farmers highlighted that social infrastructure and amenities are vital to reduce the effects of drought (Table 4.28). This includes proper water supply, good roads, alternative jobs and social support. Although having these and other infrastructure is not expected to solve the problems of drought, it is believed that these will reduce human suffering and induced environmental degradation (Eludiyon *et al*., 2017). It is envisaged that however, these opportunities will make farmers self-reliant and create other commercial opportunities. Figure 7.2 is a flowchart that shows social impacts drought mitigation framework. This shows the process to following in mitigating the impacts of drought.

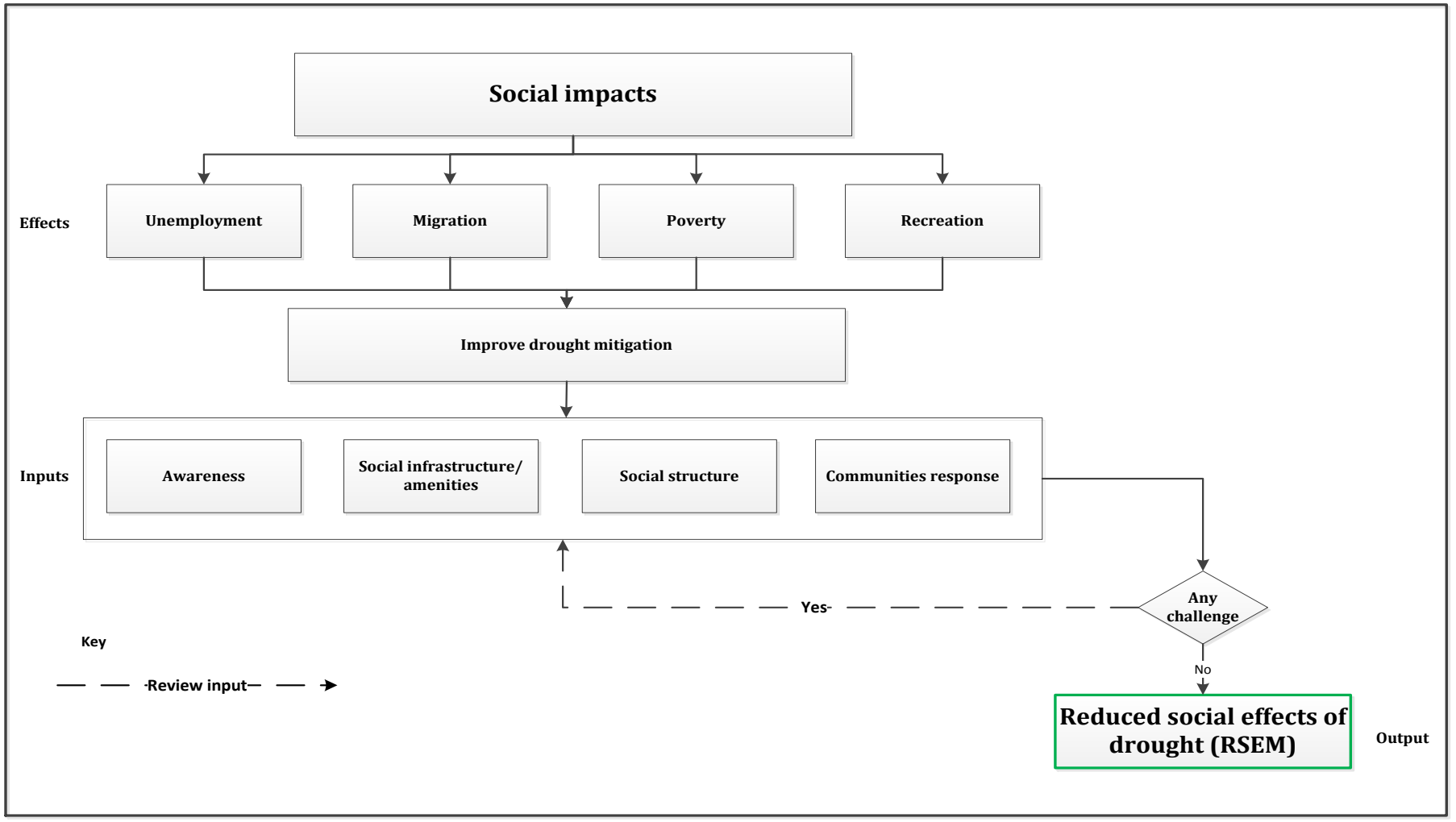

Figure 7.2: Social impacts mitigation framework.

7.4.2. Economic Impacts Drought Mitigation Framework

These are measures to mitigate economic effects of drought in Yobe state. These include:

Research and expertise: Research into drought (e.g. weather forecasting, drought modelling, cloud seeding, water management and improved crops) are important mitigation tools, in both the short and long-term. Research can provide up-to-date information of conditions within the State. This will also provide opportunities to discover water efficient seed varieties, animal feed and socio-climatic changes. Expert input in the process of drought mitigation is very important and can provide the most feasible approach to address to drought problems, for instance advising on agroforestry and crop rotation. These can also be addressed through collaboration efforts between academic institutions and communities. Experts will help communities improve their practises, which will also provide opportunities for research. They can also monitor people/communities progress both socially and environmentally, based on the practise.

Sustainable irrigation practise: this measure has been emphasised in both the assessment (survey and FGDs) and other many studies (e.g. Abubakar and Yamusa, 2013; Eludiyon *et al*., 2017). Sustainable irrigation practise is one of the most effective strategies to curtail the impacts of drought, especially in rain-fed farming regions and it will help reduce harvest loss. It will also improve revenue generation for the State through taxation of produce sold in markets. The emphasis on adopting sustainable irrigation practise is very important to avoid depletion of water resources, water pollution and increased soil salinity. Water catchment areas can be identified in the State for project initiation (pilot project). This can also be carried out in different phases, depending on what crops grow best in different parts of the State. Training farmers on how to properly irrigate is important in order to reduce risk of improper irrigation practises.

Modern irrigation infrastructure should be provided to farmers. This equipment can help reduce water wastage and environmental degradation. However, irrigation alone cannot solve drought problems and supporting strategies should be included. Sustainable irrigation practise is important, because it assists water efficiency, uniformity and reduces contamination. Producers should evaluate their farming system, as every farm would have techniques suitable to them. Irrigation scheduling, soil and crop properties, improved irrigation technologies and managing surface irrigated fields are some sustainable irrigation practises measures (Reagan, 1994). Other pollution management measures include salinity management, crediting nitrate in irrigation, limited irrigation, landing levelling, managing application and determining leaching hazards (Reagan, 1994). Application of all these measures requires expertise and training for the project to succeed.

Fertilizer supply: During the FGD with farmers they emphasised their need to have access to fertilizers. Providing affordable inorganic fertiliser would improve growth and reduce harvest delays and showed that usage of fertilizer increase yield (Denning *et al*., 2009). Long gaps between rainfall events in a season cause much crop damage. It is important to educate farmers on proper timing and quantity of fertiliser applications. Inappropriate timing and quantities can diminish fertiliser efficiency. Organic fertilisers can be improved and used to reduce environmental effects of fertiliser application. Inorganic fertilisers need water in order to penetrate into the soil. According to Yobe rainfall data there is rainfall every year despite the general decrease.

Supply of improved seeds: Farmers emphasised their need to access improved crop seeds that can withstand or resist drought, to help reduce their harvest loss and increase harvest yield. Collaborating with State and Federal Agricultural Research Institutes, universities and various Ministry of Agriculture (Federal and State) will help produce improved seeds through

Pest control: It is important that controlling pest invasions is given priority. For exotic insect pests, establishing classical biological control should be a priority, particularly in perennial or stable habitats. Types of invading pests should be identified across the State and the most suitable environmentally-friendly pest control techniques should be adopted. Both FGD sessions established that pest control is vital in the State.

Access to market: In order for farmers to be more self- reliant it is advisable they diversity their sources of income to reduce risks of drought shock. They should be trained and be given opportunities to access markets with their farm produce.

Establishing food reserves: food reserves are important both before and during drought. Establishing and managing food reserves slow increases in food prices during drought and play vital roles in supplying areas critically in need (Abubakar and Yamusa, 2013). Government or communities can create programmes where after every harvest, farmers can sell some of their crops to the reserves, where during drought food can be subsidised. Collaborating with the Federal Food Reserves of the Federal Ministry of Agriculture will increase the efficiency and scope of food reserve programmes.

Loans/insurance: Farmers strongly agreed that loans or insurance can mitigate drought shock during and after events. Providing loans and insurance to drought victims (farmers) will serve as a safety net. Providing enabling environments through approved platforms can allow access to loans from either commercial banks or government agencies, especially during extreme events. The loans can support farmers' diversify and provide opportunities to access mechanised equipment.

Insurance for farmers will provide alternative support to withstand drought shock. If possible, it will help them establish other sources of income, instead of selling their livestock and resorting to environmental degradation. Australia has introduced insurance for drought

victims and it proved successful for proactive drought mitigation (White *et al.*, 2005; Bond *et al*., 2008). These are actions and strategies that would be in place for farmers before drought events. Figure 7.3 is the flowchart of the Economic Impacts Drought Mitigation Framework.

Grazing reserves: Creating grazing reserves for farmers rearing livestock with proper infrastructure will serve as sources for animal feed before, during and after droughts. Daily (2018) reported conflicts between farmers and herdsmen. Educating farmers and herdsmen on the importance of destocking and using grazing reserves will reduce such problems. Fertile lands within the State can be used to establish grazing reserves for pastoralists, thus reducing over-grazing of marginal land and environmental degradation (NDDP, 2007). Proper infrastructure should be provided within the reserves, for example, water supply and fences to restrict livestock movements. Using fertile land will require significant amount of rainfall to maintain the reserve.

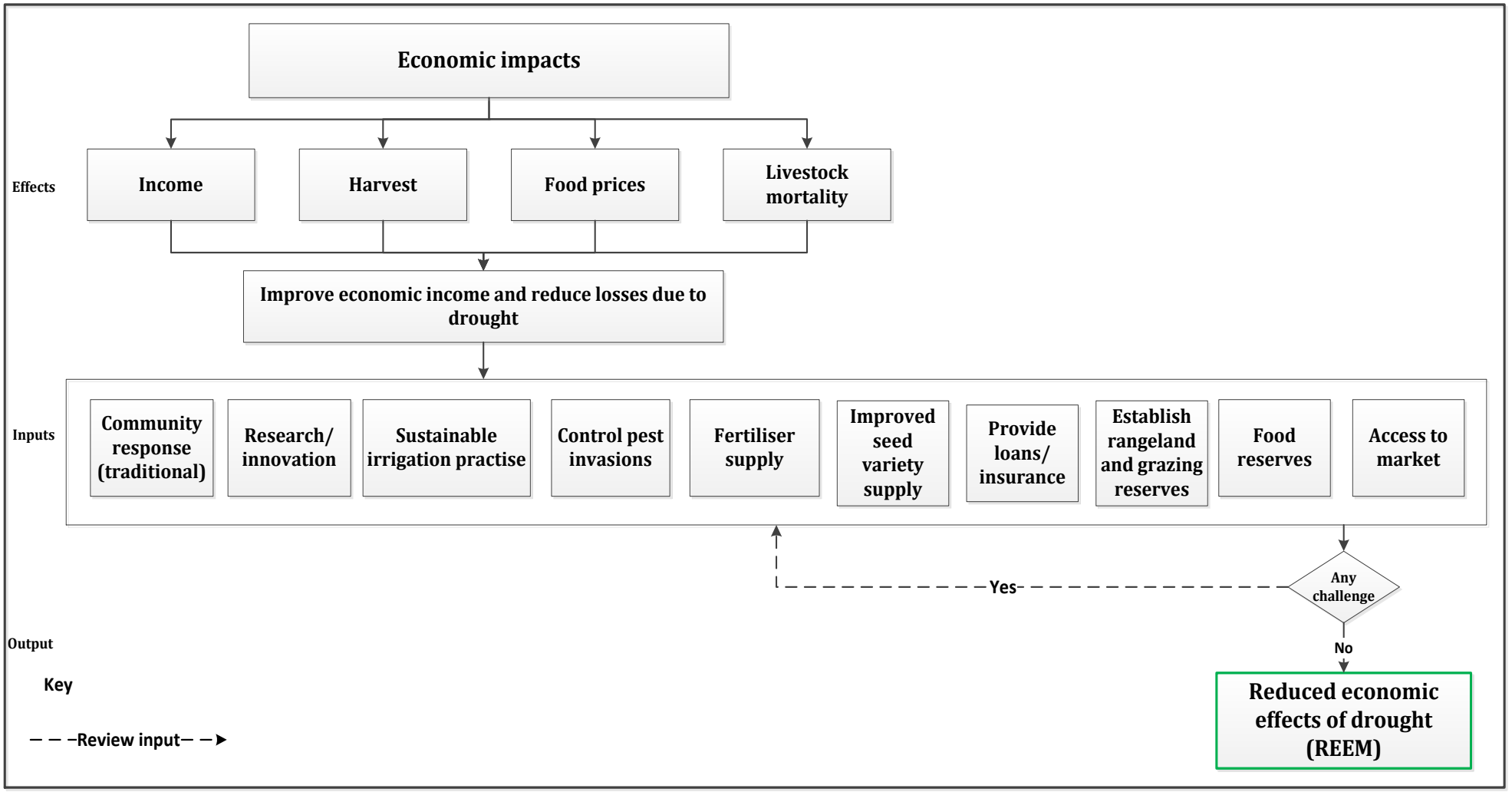

Figure 7.3: Economic Impacts Mitigation Framework.

7.4.3. Environmental Impacts Drought Mitigation Framework

These are measures to mitigate impacts of environmental drought effects in the State. **Afforestation and reforestation:** Establishing and restoring forests is important to reverse environmental degradation and provide habitats to affected organisms. This can also be done by empowering local farmers to grow seeds in nurseries and be given incentives. This has worked in some communities in north-west Nigeria, as part of efforts to combat desertification (FME, 2012). Forest ecosystems provide numerous environmental services, including reducing soil erosion and desertification and increasing soil organic carbon content. However, reforestation requires proper management and sustainable environmental law enforcement to improve forest protection. These measures have yielded positive results in other countries (Section 2.5.5.2).

Crop rotation and timing: For proper soil management and land use, crop rotation and timing are vital. Crop rotation usually helps maintain soil fertility and serves as an alternative if there is no access to improved seed varieties. Timing of planting is important, as improper timing can exacerbate drought impacts. These techniques improved soil fertility in semi-arid region in Kenya (FAO, 2018). Engaging farmers in these practises will stress the importance of environmental stewardship.

Conservation of water resources: Maintaining and managing water resources in the State is important for water security and will enable the implementation of many drought mitigation measures (e.g. irrigation, grazing reserves and afforestation). Conserving both surface and subsurface water resources will reduce water pollution and habitat disturbance.

Woodlot establishment: Many people fell trees as a drought-coping strategy to reduce income shock. Establishing woodlots for fuel-wood will reduce this pressure (NDDP, 2007). These woodlots can be established in different parts of the State, to allow access to many

people. This will also reduce risks of wildlife habitat loss. Lack of access to electricity, cooking gas and cooking fuel/kerosene leaves people with no option, but to cut down trees for energy in their homes for cooking and heating during the cold season (NDDP, 2007). However, some people use trees as timber for construction. Thus, woodlots will provide alternative sources of fuel-wood for energy and construction.

Reduce hunting of wildlife: Preventing wildlife vulnerability and extinction is very important in current environmental conservation measures. Farmers often resort to hunting during drought. However, effective and managed hunting is commendable as a conservation measure. According to MoE officials problems of illegal hunting and poaching of wildlife is a major issue in the State and there is no proper law enforcement to prevent these activities.

Land use management: Bush burning, overgrazing and over-harvesting have been some of the major environmental threats in the State. Proper land use management will improve land use, reduce land degradation and desertification. Improper land management will increase the risks of desert encroachment in communities, which render farmlands infertile for harvest.

Law enforcement: This strategy would play a vital role in reducing environmental degradation in the State. Officials from the Ministry of Environment emphasised proper law enforcement, especially regarding deforestation and poaching. However, for the law to be implemented and enforced, alternative sources of energy and means of livelihood are needed. The Environmental Mitigation Framework is presented in figure 7.4.

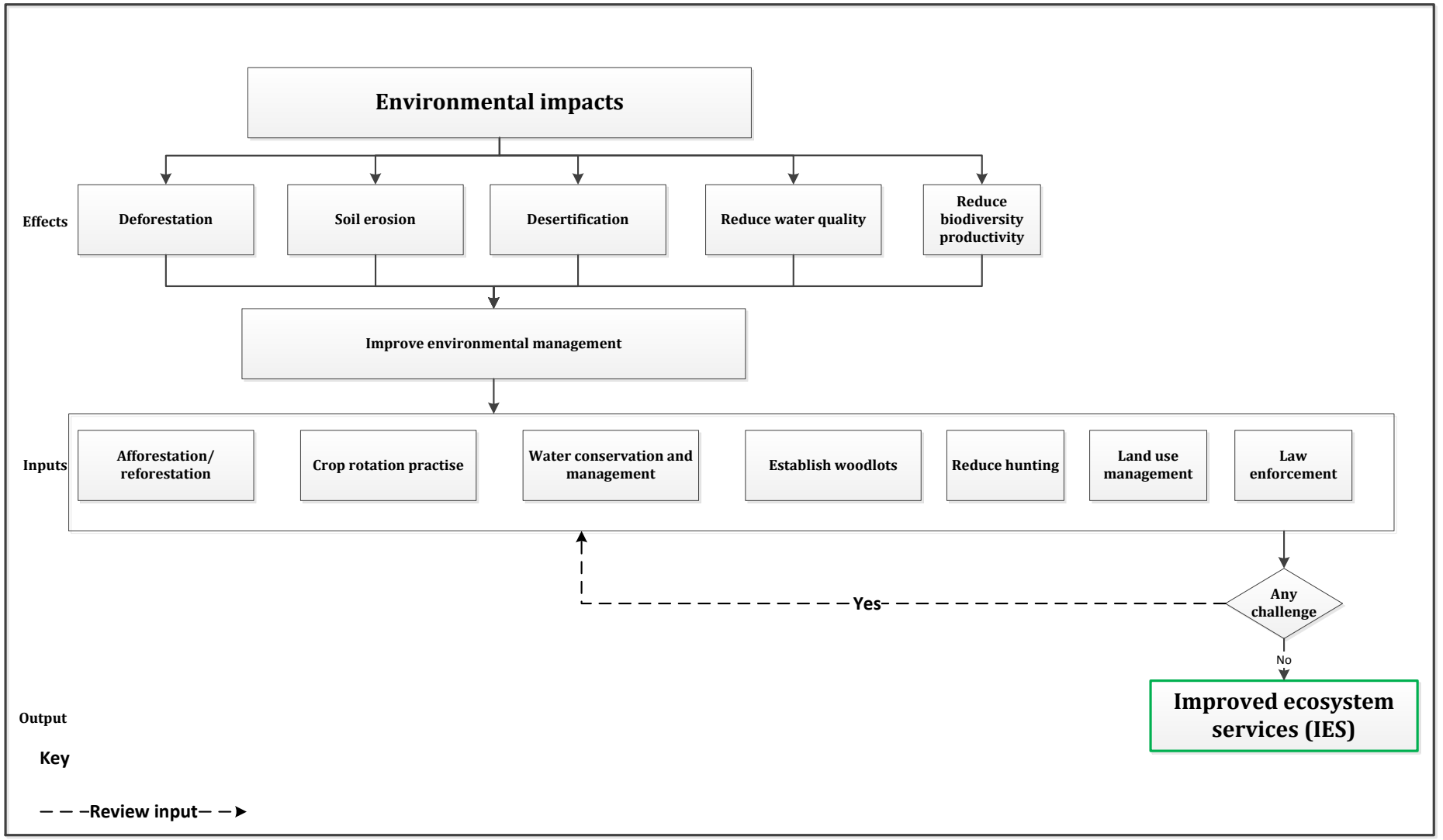

Figure 7.4: Environmental Impacts Mitigation Framework.

Communities and government can sign a commitment agreement where both parties will ensure that they play their part in drought mitigation programmes. This will also reduce negligence by both parties.

7.4.4. Sector frameworks implementation

Several major steps need to be taken to implement the Frameworks (Table 7.1). All the frameworks should be implemented at community levels. Implementing the Integrated Framework will assist proactive processes of drought mitigation in Yobe State.

Table 7.1: Sector frameworks implementation process

S/no. steps	Strategies	Actions
1	Identify areas that need intervention	Needs assessment should be conducted before, during or after drought to identify areas that need intervention. This is to help reduce the cost of implementation and ensure areas of need are covered.
2	Community structure	All communities that need intervention must have a platform or structure for easy intervention and support. This will make it easier to educate and provide support.
3	Awareness	Step 3 is to educate farmers on the need for the projects and how they can maintain them. Every strategy requires the provision of farmers education.

7.5. Drought management strategies

These are strategies to mitigate and manage drought in the State, and should prioritise proactive measures.

Early Warning Systems: These can be established to generate timely information and build needed capacities prior to drought. Providing drought Early Warning Systems in Yobe State will mitigate both drought impacts and reduce direct environmental degradation. Reliable information is a major parameter for adequate Early Warning Systems which can be achieved by having infrastructure to support the systems. Establishing weather stations within all

LGAs in the State with advance drought forecasting tools are integral to Early Warning Systems. This is important to improve prediction of drought onset, cessation, duration and distribution. The Yobe State Government can share data with the NiMET. This research has identified both socio-economic and climate parameters to project and assess drought impacts in Yobe State including harvest output, livestock mortality, migration due to harvest losses, water levels, rainfall, temperature and humidity.

These parameters can be used to develop a drought projection and impact tool. Sowing and harvesting time can be projected and assessed with proper Early Warning Systems to reduce harvest losses. The Nigerian Government is improving Early Warning Systems by providing well equipped weather station in drought and flood affected areas (FGN, 2005). In 2016, when rainfall data for this research was applied through NiMET, there were only two old weather stations in Yobe (Nguru and Potiskum). These are signs of failed government efforts in implementing drought proactive mitigation policies, as much necessary infrastructure is not available in the State. Early Warning Systems should be integral parts of decision making and drought mitigation (Thomson *et al.*, 1998; Wilhite *et al*., 2005).

Preparedness: Having Early Warning Systems should be complimented by proper action plans. Proper planning measures are necessary before, during and after events, to enable speedy recovery. Community and individual resilience can be achieved with prepared action plans. Expected vulnerable areas of potential drought impacts and their extent can be identified with proper preparedness measures.

Communication: Effective Early Warning Systems and preparedness require adequate communication systems. Communication gaps and inconsistency can be the difference between mitigating extreme drought impacts and having major losses (Wilhite, 2016).

During the FGD some officials raised concerns on the problem of communication gaps between farmers, residents and government. For example, the problems of deforestation were communicated to people, but remain a problem in the State. In order to have adequate communication there is a need to have structures that can channel information from the government through regions, local governments and communities in the State. TV, radio stations and the internet, social media provide important communication tools. Increasing awareness and educating people on drought can help bridge communication gaps. This is important because of cultural and religious barriers; some people will not believe information provided (West *et al*., 2008), especially weather forecasts. The conflict between science, culture and religion are major challenges to achieving effective communication (Habiba *et al*., 2012). These problems can be addressed through consistent public awareness via community and religious leaders.

Social welfare*:* Farmers strongly agreed that social welfare can mitigate the effects of drought in the State. This action can only be taken by governmental organisations, because it is expensive. Providing social systems that support drought victims without financial repayment will decrease both poverty and environmental degradation. Severely affected farmers can be prioritised for this type of support (Jenkins, 2012; Eludiyon *et al*., 2017; Wossen *et al*., 2017).

Relief materials: Supplying relief items during and after drought has been the major action taken by the State Government; but has proved unsuccessful. Shifting to proactive measures is expected to be more effective. Some of the major challenges of using relief are timely intervention and quantity. Most interviewed farmers never received relief or support. Most relief items usually arrived late and were insufficient for the affected people. Transportation and accessibility can also pose problems for delivering relief and social amenities and infrastructure play vital roles.

Water management: Having an effective water management strategy is essential. Water management should be regulated by government agencies to minimise waste and create awareness of the importance of water conservation. The water management strategy should include projection of population growth and water needs. Rain harvest provides important water management tools and irrigation to encourage water stewardship.

Drought mitigation task force: Government find it difficult to treat drought as multi-sectoral issues. In order to treat and properly implement drought mitigation in Yobe State, a task force should be established by the State Government. The task force should bring together experts (from various government agencies and academic institutions), policy and decision makers', representatives of community, platforms and traditional leaders. The task force should also assist in proper interpretation and dissemination of information and help reduce drought mitigation costs.

7.5.1. Drought policy as part of the framework

Drought policy is an essential part of the Integrated Drought Mitigation and Management Framework, but requires political will for implementation. The Framework can be adopted without it being a policy, but this will limit its effectiveness. MoE officials recommended that the Framework becomes Government policy if it proved successful. The framework should be further reviewed before adoption as government policy.

7.5.2. The Integrated Framework

The Integrated Framework comprises of *inputs* and *outcomes*, whereas the sector frameworks have *effects*, *inputs* and *outputs*. It is referred to as an Integrated Framework as it comprises only the outputs of all the sector frameworks. The Integrated Framework can only be implemented if the other three sector frameworks are implemented. Understanding the three frameworks will provide clear knowledge of the Integrated Framework.

Input 1: these are the outputs of the Socio-economic and the Environmental Frameworks and drought management through Early Warning Systems. All sector drought effects are addressed in the three sector frameworks. The Integrated Framework uses the outputs from the three sector framework to mitigate and manage drought impacts.

Input 2: these are proposed strategies used in the Integrated Framework, which will help achieve the desired outcomes. It comprises of policy, drought mitigation task force and implementation challenges.

Outcome: the final outcome of the Integrated Framework is to achieve sustainable drought management that will improve living conditions, achieve productive communities and improve environmental conditions that can help communities cope with future extreme weather events. This is a long-term outcome which can only be achieved by consistency in drought mitigation actions and management.

Implementing the integrated framework means that holistic and the most suitable measures of drought mitigation are considered. In order to have sustainable drought mitigation and management that secures both environmental quality and socio-economic growth, implementing the Integrated Framework is vital. The whole process can be achieved by reviewing and evaluating the measures during and after implementation. If there is the intention to make it a policy, then challenges should be addressed. The robustness of the Framework determines its level of achievement. However, to achieve mitigation management, reviews, monitoring, evaluation and research into drought problems is recommended.

7.5.3. Importance of implementing the Integrated Framework

Implementing the Framework for drought mitigation and management is challenging. Taking only some of the strategies within the Framework to combat drought impacts would not yield

expected results. For example, farmers believed that irrigation, relief and water supply or afforestation would mitigate drought. However, integrating the complete Framework strategies would be more effective in combating droughts. The Framework will assist in providing drought contingency plans before, during and after droughts. The use of satellites and other remote sensing technologies to project and monitor drought would be vital. It is important to have both short and long-term drought management due to *resource* and *cultural* constraints. There are numerous challenges and constraints related to implementing the Framework, including: infrastructure, resources, planning and expertise.

The presence of proper infrastructure will support implementation, including technologies and experts at weather stations. Some strategies are capital intensive, this is one of the reasons the frameworks are split. Expertise is required in order to implement some of the strategies, for example, irrigation through sustainable practises and drought prediction. Without proper and timely planning, even after implementing the Framework, success would not be achieved. This could be due to poor timing and intervention. It is recommended that communities and NGOs can use any of the sector frameworks. If government intervenes, it is expected that they implement the Integrated Framework. However, if NGOs can afford to implement the Integrated Framework, it will be suitable for drought mitigation and management in Yobe State. Figure 7.5 presents the Integrated Framework, which is the outcome of the study.

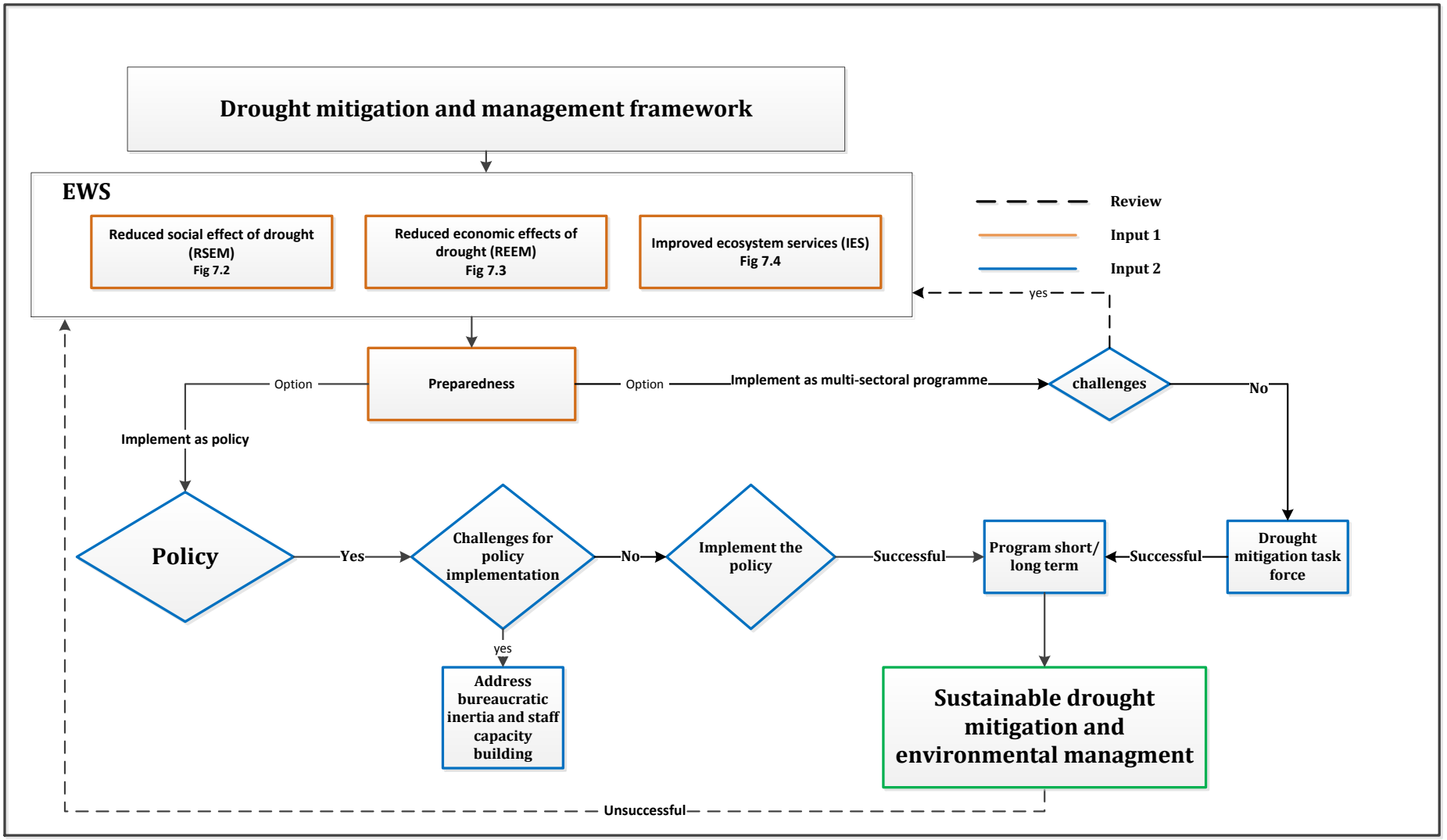

Figure 7.5: Integrated Framework.

7.6. Framework evaluation process

In order to assess the robustness, transferability and workability of the frameworks, a before-use evaluation was conducted. This was done to assess the extent to which effects of drought can be mitigated in Yobe State. Participants from the Ministry of Environment and farmers were invited to evaluate the proposed frameworks. The frameworks were presented in the form of flowcharts, with detailed descriptions given to the Ministry of Environment officials. For the farmers, the sector frameworks were presented for evaluation, whereas officials from the Ministry of Environment were requested to evaluate all the frameworks. The four farmers who took part in the validation process are identified by codes (e.g. farmer V1, V2, V3 and V4).

7.6.1. Framework evaluation responses from farmers

Four farmers from FGD participants were contacted for the interviews. All the questions for the framework evaluation are presented in Appendix F. All the farmers considered awareness, supply of improved seeds, fertiliser supply and pest control as their main concerns and further stated that if all these measures are in place they will drastically mitigate the impacts of drought. They also believed that it is important for farmers to take some responsibilities. Irrigation is feasible through boreholes, but infrastructure and funding are associated problems. In the past, a village in the area had a pilot irrigation project and was successful, but the project only lasted for three years due to funding constraints. Farmer VII said "*if all these proposed measures are implemented and sustained it will change so many lives*".

In 2016 they had ~60 days without rainfall, but eventually floods occurred during the rainy season. Farmers were interested that awareness and community structure are part of the proposed strategies and they stated this gave them hope and confidence that they will be part of the process. They stated that they were very unhappy that no serious measures were taken

on drought despite it being pronounced in the State. Farmers have shown their interest and are ready to take part in effort that will reduce their suffering due to drought.

7.6.2. Evaluation responses from the Ministry of the Environment officials

Follow up interviews were conducted with Ministry of the Environment officials. Directors who participated in the FGD were contacted for before-use framework evaluation. Among the five directors, the two who responded were: the Director of 'Drought Desertification and Climate Change Amelioration' (DDC1) and the Director of Forestry and Wildlife' (DFW1). Both believed that the proposed sector frameworks could mitigate the impacts of drought. However, on the issue of farmers' responsibility, their opinions differed. They both believed that farmers' responsibility will only mitigate drought to some extent, but DFW1 emphasised the need for awareness before this can be achieved. Involving farmers in mitigation and management processes will help farmers' preparedness and supporting them in being self-reliant. Awareness is one of the barriers that can affect the success of the frameworks. Both Directors maintained that the frameworks are applicable and practical. However, they commented that the Economic Mitigation Framework might be capital intensive. According to DDC1 "*the frameworks are very much relevant to the drought situation in Yobe State*".

7.6.3. Farmers' and Ministry of the Environment officials views of the frameworks

Farmers' stressed the need for improved seeds, fertiliser and proper pest control. Improved social infrastructure could also decrease drought effects. According to the farmers, irrigation is feasible through boreholes. All efforts towards drought mitigation without adequate farmers' awareness will eventually fail. Having drought mitigation measures in place can mitigate the impacts, but sustaining them for drought management is vital. Farmers' accessibility to loans is important, but difficult. Farmers stated that they have never known any farmer within the State that had access to agricultural loans in the past 45 years. However, lack of access to such loans and associated infrastructure, negatively affect farmers

in Yobe State. Inappropriate costing and insufficient funding would negatively affect framework implementation in Yobe State, which makes it important to estimate the cost of framework implementation. MoE officials stated that awareness and funding are vital issues. If these are not given proper attention, the frameworks might not achieve the desired objectives. It is expected that if the frameworks are properly implemented there will be a sustainable socio-economic and environmental development in the future. From the information gathered during the framework validation process, no participants (farmers or MoE officials) suggested any changes to the frameworks, rather they emphasised priorities.

7.7. Summary

Strategies were proposed to mitigate and manage drought in Yobe State. Four drought mitigation frameworks were developed including: Social Impact Mitigation Framework, Economic Impact Mitigation Framework, Environmental Impact Mitigation Framework and the Integrated Framework. The Social, Economic and Environmental frameworks are referred to as sector Frameworks and the Integrated Framework.

The frameworks were divided in order to encourage micro-drought mitigation intervention at all levels. All the possible steps required for mitigation and implementation processes at all levels were discussed. For the Integrated Framework it is necessary that all the outputs in the sector frameworks are implemented before use. The inputs of the Integrated Framework are the outputs from the sector frameworks. It can also be used to implement proper drought mitigation and management policy. The frameworks are expected to be regularly reviewed and evaluated.

Based on the developed frameworks, it was necessary to assess the robustness, transferability and workability of the frameworks. This will also increase the credibility and reliability of the frameworks to stakeholders. Before-use framework evaluation was conducted to ascertain if

the frameworks could mitigate the impacts of drought in Yobe State. Farmers and officials from Ministry of Environment were used to evaluate the frameworks. Both groups confirmed that if the frameworks are implemented, they will mitigate the impacts of drought in Yobe State.

CHAPTER EIGHT: CONCLUSIONS AND RECOMMENDATIONS

8.1. Introduction

This chapter reviews the extent to which the aims and objectives of the research have been achieved. The chapter collates all findings from the study to make conclusions and recommendations for drought mitigation and further studies. The contributions of this research to knowledge are also presented.

8.2. Achievements of research Aims and objectives

The research had two research aims and five objectives relating to drought in Yobe State (Section 1.6). The extent to which the aims and objectives of this research were achieved, is presented in this section.

8.2.1. Achievement of aim 1 and objectives

Aim 1: ***Assess the damage caused by drought to farmers' livelihoods and the environment. This is by collecting data from drought victims (farmers) to assist in proper planning and preparedness.***

To achieve this aim, assessment of drought impacts was conducted to understand how drought affects farmers' livelihoods. Questionnaire survey and FGDs were conducted and the results were presented in Chapters 4 and 5. Based on these findings, the study assessed the level of drought impact and damage to the environment. Prior to this research, there had been no study that assessed drought impacts in northern Nigeria. Investigating these impacts helped in developing mitigation methods.

Objective 1: *Investigate social responses at community level in order to help mitigate drought. This is to understand how farmers respond to drought traditionally. It would also help in organising local mitigation strategies to make farmers more self-reliant.*

It was important to investigate social response in the Yobe State and include farmers'

traditional methods of drought mitigation into the strategies proposed by this research. However, there were different views on social response at community level by farmers. Some respondents stated that it is hard for them to practise their traditional mitigation methods at community level, whereas others practised Katifu and Miski (Chapters 4 and 5).

Objective 2: *Investigate the environmental effects caused by drought coping strategies. In order to reduce environmental degradation caused by drought in Yobe State. This was conducted through literature review and empirical studies.*

Investigating environmental impacts caused by drought coping strategies in Yobe is important to reduce environmental degradation and improve land use management (Chapters 2, 4 and 5). Farmers in Yobe State practised over-grazing, bush burning and over-harvesting, these are due to the harvest loss and livestock mortality caused by drought.

Objective 3: *Investigate spatio-temporal rainfall trends in Yobe State to understand which part of the State receives less rainfall. The analysis was based on, 25 years (1990-2005) of rainfall data collected from the Nigeria Meteorological Agency (NiMET).*

NiMET data shows that Yobe State receives very little rainfall compared to the national average and less than average of the Sahel region. (Chapter 1, Figures 1.4 and 1.5).

8.2.2. Achievement of Aim 2 and objectives

The second Aim was: ***To develop a framework for the amelioration of drought in Yobe State as a planning and management tool for the State Government and other stakeholders.***

Three sector frameworks (social, economic and environmental) for drought mitigation were developed and integrated into one drought mitigation and management framework (Chapter 7). It is believed that the proposed frameworks would reduce the impacts of drought. In order to achieve Aim 2, two research objectives were investigated.

Objective 1: *Produce frameworks that can be used by stakeholders to mitigate impacts of drought. This will reduce the cost of drought mitigation for both communities and government by using different drought mitigation measures.*

This objective was achieved by producing different sector frameworks that can be used by stakeholders at all levels to mitigate the impacts of drought in Yobe State. The frameworks were developed based on the reviewed literature and findings from the empirical studies in the field (Chapter 7, figures 7.2, 7.3, 7.4 and 7.5).

Objective 2: *Assess and evaluate the robustness and transferability of the proposed frameworks. This was conducted by collecting empirical data from the potential framework users.*

The research conducted a before-use evaluation of the frameworks to assess the robustness and transferability of the frameworks (Chapter 7). Respondents from both FGDs were contacted via phone to ascertain if the strategies in the frameworks had potential to mitigate impacts of drought in Yobe state. The responses from both farmers and Ministry of Environment officials revealed that they are confident that if the measures/strategies are properly implemented, there is potential to mitigate the impacts of drought in Yobe State.

8.3. Summary of findings from the study

Studies have shown that drought research is important, especially in regions with extreme climate variability (Wilhite, 2005; Mishra and Singh, 2010; HMNDP, 2013; Mishra *et al*., 2015). This research reviewed the literature on the effects of drought around the world. In Nigeria, Shiru *et al*. (2018) and rainfall data from Yobe State suggest that drought has been increasing in Nigeria and particularly in Yobe State. Questionnaire surveys showed that farmers believed that drought has been frequent in recent years.

Different measures have been undertaken to mitigate and manage the impacts of drought. In this regard, drought mitigation measures and policies of different countries and Nigeria were reviewed. Generally, drought has received insufficient global attention, thus affecting the mitigation measures (HMNDP, 2013). Some Sahelian countries have not focused on providing safety nets to farmers in the region (Shiferaw *et al*., 2014). In Nigeria, there have been several policies and efforts, but most failed to address the impacts of drought. The Nigerian Government needs to change its approach and improve efforts to mitigate the impacts of drought. Lack of political will, corruption and weak institutions caused the failures of many policies and strategies. Other factors that negatively affected government policies' implementation in Yobe State include insufficient funds, bureaucratic processes and capacity. During the FGD with Ministry of Environment officials, it was suggested that proper implementation of drought mitigation policies by government will reduce its societal impacts.

The research collected data on the impacts of drought in Nigeria, with emphasis on Yobe State. The results showed that drought has negatively affected many farmers in Yobe, of which most solely relied on agriculture for their livelihoods, often most of their harvests and livestock have been lost. Farmers in the State find it difficult to afford basic necessities. Farmers often migrate and leave their families behind, very few were able to move with their families. This is affecting their way of life and making them more vulnerable to future droughts.

This research established that there is severe environmental degradation and improper land management in Yobe State, including bush burning, deforestation, overharvesting and overgrazing on marginal land. Farmers overwhelmingly believed that their activities affect the environment (Table 4.25, Section 5.3). Proper agricultural practises and support for farmers will reduce the rate of environmental degradation caused by farmers in Yobe State. This can be achieved through training, education and proper land use management.

8.4. Contributions to knowledge

The developed frameworks can facilitate mitigation of drought effects in Yobe State. The depth and information collated in the study has produced identifiable contributions, to theory, methodology and practise.

8.4.1. Contributions to theory

Numerous studies have defined drought in different ways depending on the context and situation (Chapter 1). Mishra and Singh (2010) and Nwokocha (2017) agreed that there is no universal definition of drought, thus making it difficult to understand. Considering that several definitions of drought have not used or mention certain attributes of drought, it is important for this research to propose a comprehensive definition. This research defined as: "*Drought is the shortage of rainfall or water that affects people's livelihood and the environment, both directly and indirectly".* It is expected that this definition will help broaden the scope of drought research.

This research has also produced a conference article and submitted two journal articles (Appendix H). These publications will serve as additional sources of information on drought. There are studies conducted on desertification and drought in Nigeria, but very few have mainly focused on drought. This research has extensively studied the problems of drought around the world and presented related issues from Nigeria. This research proposed new paradigm, which integrated proactive and reactive measures and a bottom-top approach to drought mitigation and management.

8.4.2. Contributions to methodology

Most efforts by government on drought mitigation have not properly involved farmers' in developing comprehensive drought mitigation plans. This research used FGDs to assess farmers' and government officials' views of drought mitigation and used questionnaire surveys to assess the level of drought impacts in Yobe State and how farmers cope with it.

This helped to show the importance of drought mitigation and its influence on policy and how drought is perceived among decision-makers.

8.4.3. Contributions to practise

This research developed drought mitigation frameworks for Yobe State, which can be used and adopted within north-east Nigeria. The study identified different coping strategies farmers adopt during droughts in Yobe State. It has also identified farmers' coping strategies within regions of Yobe State, as each region uses different measures to cope with drought shock. The research has contributed to the search for solutions for coping with drought, by encouraging drought victims and farmers to be more self-reliant, by giving them some responsibility, rather than simply relying on relief and other support items. If these are practised, future generations will be more self-reliant and this will improve drought mitigation strategies. Three sector frameworks were developed, considering communities, donors and stakeholders involved in drought mitigation. Considering all relevant parties is vital in achieving the desired objective of reducing the impacts of drought in Yobe State. This research developed a framework that Yobe State Government can implement as part of drought policy. There was no drought mitigation and management policy in Yobe State prior to this research. The frameworks were evaluated before-use through responses of participants. The study produced a comprehensive framework that can potentially ameliorate the effects of drought in the State. The research achieved its main aim by developing a comprehensive Integrated Framework for drought mitigation in Yobe State.

8.5. Conclusions from the research

Drought is a major challenge to many communities and farmers in Yobe State. Most farmers in Yobe State have no alternative measures to reduce drought shock, as farming is their sole source of income and is extremely challenged by severe droughts in the State. Their means of coping with drought is through improper agricultural practises that cause land degradation.

Farmers stated that their major problem is rainfall, which they said has been inconsistent in recent years. Average rainfall received in Yobe State showed that it receives less than a quarter of the national rainfall average (Section 1.4.3). Droughts in Yobe State have led to mortality of livestock, severe harvest losses and pest invasions.

Predicted climate-related events will increase in the future (IPCC, 2001; 2007; 2014), thus drought mitigation is vital to avoid humanitarian crises. This research argues that drought management in Nigeria needs to be proactive to reduce costs, and impacts on communities and the environment. Stakeholders and governments need to step up to reduce drought impacts, as traditional and reactive measures are not working at community levels (Chapter 5). It is believed that the frameworks proposed in Chapter 7 would help in drought mitigation and management in Yobe State. Hence, if implemented it could reduce farmers' drought shock by improving their living conditions and thus reducing poverty. At the same time, the application of the frameworks will reduce excessive environmental degradation and improve environmental management in Yobe State.

8.5.1. Limitations of the study

A key limitation of this research is the exclusion of women during the data collection process. In the study area, women do not usually own farms, they are mostly owned by their husbands or family. Due to cultural and religious reasons, women were not involved in the process and this may have negative impact on the outcome of this research. Further studies are recommended and should include the views of entire community, including women. Investigations are recommended on the impacts of drought on the non-farmer (residents) of the State and the use of other meteorological data to fully understand drought patterns in the State. Due to insufficient time and data this research was unable use different meteorological data for the study.

8.5.2. Recommendations from research outcomes

1. This research recommends that Northern Yobe State should be considered for early and timely intervention before, during and after drought, as it is the most vulnerable region within the State.
2. It is envisaged that the findings would be used as a reference for policy-making and legislation in Yobe State.
3. Yobe State Government can use and implement the developed frameworks as a means of drought mitigation and management.
4. The three sector frameworks should be implemented. Stakeholders can implement any framework that suits their needs, while the Integrated Framework should be implemented by government.
5. The Framework should be evaluated and reviewed over time, to evaluate effectiveness and improve the frameworks.
6. If the Frameworks are successful, they should be transformed into projects and long-term programmes.
7. More weather stations, technology and expertise should be provided to help investigate drought impacts and preparedness processes.
8. All stakeholders should be included in the process of drought mitigation in order to achieve sustainable growth.

8.5.3. Recommendations for further research

Further research on drought is recommended including:

1. There should be further research to assess the value and cost of damage caused by drought in Yobe State. Research on how drought affects both subsurface and surface water bodies is required, in order to understand future threats to water resources due to population growth and environmental degradation. This can be conducted by

investigating how water resources are used and what affects their recharge based on human and environmental changes in the study area.

2. Further research using climate parameters should be used to develop a weather model that can analyse the severity and magnitude during and after droughts in Yobe State for planning and preparedness purposes.
3. There is no comprehensive study that evaluates the outcome of Nigerian Government policies on drought. It is therefore important to study and evaluate the successes of these policies and make recommendations on how to improve them.
4. It is recommended that investigation should be conducted to assess environmental variables that cause harvest loss in Yobe State apart from rainfall as used in this research; this will help improve drought mitigation and management in Yobe State. For example, investigating other meteorological variables such as humidity and temperatures will provide more understanding to how drought affects the study area. Soil type and crops produced should also be investigated as these will also influence harvest loss and pest invasions.

References

Aakre, S., Ilona, B., Reinhard, M., Dirk, R., Wreford, A. and Harvir, K. (2010) Financial adaptation to disaster risk in the European Union. Identifying roles for the public sector. *Mitigation Adaptation Strategy Global Change*, **15**: 721–736.

Abate Z. (1994) Water resources development in Ethiopia: an evaluation of present experience and future planning concepts. *Ithaca Press*, UK 206 pp.

Abdullahi, A.B., Iheanacho, A.C. and Ibrahim, A. (2006) Econometric analysis of the relationship between drought and millet production in the arid zone of Nigeria: A Case Study of Borno and Yobe States. *Journal of Agriculture and Social Science*, **2**(3): 170–174.

Abubakar, B.M. (2013) *A Framework for utilising lean construction strategies to promote safety on construction sites*. PhD Thesis, University of Wolverhampton.

Abubakar, I.U. and Yamusa, M.A. (2013) Recurrence of drought in Nigeria: Causes, effects and mitigation. *International Journal of Agriculture and Food Science Technology*, **4**(3): 169–180.

Adeaga, O. (2011) Drought risks and impact on water resources in part of northern Nigeria. Hydro-climatology: *Variability and Change*, **344**: 1–6.

Adefolalu, D.O. (1986) Further aspects of Sahelian drought as evident from rainfall regime of Nigeria. *Archives for Meteorology, Geophysics, and Bioclimatology*, **36**: 277–295.

Adger, W.N. (2003) Social capital, collective action and adaptation to climate change. *Economic Geography*, **79**: 387–404.

Adger, W.N. and Barnett, J. (2009) Four reasons for concern about adaptation to climate change. *Environmental Planning*, **41**: 2800–2805.

Adger, W.N., Arnell, N.W. and Tompkins, E.L. (2005) Successful adaptation to climate change across scales. *Global Environmental Change*, **15**(2): 77–86.

Adogi, M. (2012) Combating Desertification in Northern Nigeria: The need for Paradigm shift. Murtala Adogi Platform https://murtalaadogi.wordpress.com/2012/01/22/combating-desertification-in-northern-nigeria-the-need-for-paradigm-shift/ (accessed 11/5/18).

Agnew, C. and Warren, A. (1996) A framework for tackling drought and land degradation. *Journal of Arid Environments*, **33**: 309–320.

Agnew, C.T. and Chappell, A. (1999) Drought in the Sahel. *Geography Journal*, **48**: 299–311.

Alam, K. (2015) Farmers' adaptation to water scarcity in drought-prone environments: A case study of Rajshahi District, Bangladesh. *Agricultural Water Management*, **148**: 196–206.

Alhassan, A.B., Carter, R.C. and Audu, I. (2003) Agriculture in the oasis of the Manga Grasslands of semi-arid north-east Nigeria: How sustainable is it?. *Outlook on Agriculture*, **32**(3): 191–195.

Alston, M. and J. Kent. (2008) The big dry: the link between rural masculinities and poor health outcomes for farming men. *Journal of Sociology*, **44** (2): 133–147.

Amaratunga, D., Baldry, D. Sarshar, M. and Newton, R. (2002) Quantitative and qualitative research in the built environment: application of "mixed" research approaches. *International Journal of Productivity and Performance Management*, **51**(1): 1–3.

American Meteorological Society, (1997) Meteorological drought—Policy statement. *Bulletin of the American Meteorological Society*, 78: 847-849.

Andreadis, K.M., Clark, E.A., Wood, A.W., Hamlet, A.F. and Lettenmaier, D.P. (2005) Twentieth-century drought in the conterminous United States. *Journal of Hydrometeorology*, **6**(6): 985–1001.

Andreu, J. and Solera, A. (2006) Methodology for the analysis of drought mitigation measures. In: G. Rossi, F. Vagliasindi, and A. Vela (Eds.) Water Resource Systems in Drought Management and Planning for Water Resources. CRC Press, Boca Raton, Florida USA, 268 pp.

Andreu, J., Ferrer-Polo, J., Pérez, M.A., Solera, A. and Paredes-Arquiola, J. (2013) Drought planning and management in the Júcar River Basin, Spain. In: *Drought in Arid and Semi-Arid Regions* (pp. 237-249). Springer, Dordrecht.

Ankrah, N.A. (2007) *An investigation into the impact of culture on construction project performance*. PhD Thesis, University of Wolverhampton.

Antwi-Agyei, P., Fraser, E.D.G., Dougill, A.J., Stringer, L.C. and Simelton, E. (2012) Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Applied Geography*, **32**: 324–334.

Arnell, N.W., van Vuuren, D.P. and Isaac, M. (2011) The implications of climate policy for the impacts of climate change on global water resources. *Global Environmental Change*, **21** (2): 592–603.

Atilola, Olusola. (2010) Global Warming and the Nigerian Environment: The Imperatives surveying and Mapping Services. Presented at the National Conference of the Nigerian Union of Planetary and Radio Sciences (NUPRS) University of Lagos, Lagos State, 12th-15th October, 2010.

Ayanlade, A., Radeny, M., Morton, J.F. and Muchaba, T. (2018) Rainfall variability and drought characteristics in two agro-climatic zones: An assessment of climate change challenges in Africa. *Science of the Total Environment*, **630**: 728–737.

Babbie, E. R. (1990) *Survey Research Methods*. Belmont, California, USA: Wadsworth Publishing Co.

Baker, M.J. (2003) Data collection - Questionnaire design - *The Marketing Review*, **3**: 343–370.

Batterbury, S.P.J. and Warren, A. (2001) The African Sahel 25 years after the great drought: assessing progress and moving towards new agendas and approaches. *Global Environmental Change*, **11** (1): 1–8.

Berkhout, F. (2005) Rationales for adaptation in EU climate policy. *Climate Policy*, **5** (3): 377–391.

Bhavnani, R., Vordzorgbe, S., Owor, M. and Bousquet, F. (2008) *Report on the status of disaster risk reduction in the sub-saharian Africa region.* Commission of the African Union, United Nations and the World Bank.

Birthala, P.S., Digvijay, S., Negib, Md., Tajuddin, K. and Shaily, A. (2015) Is Indian agriculture becoming resilient to droughts? Evidence from rice production systems. *Food Policy*, **56**: 1–12.

Blunden, J., Arndt, D. and Baringer, M. (2011) State of the climate in 2010. *Bulletin of the American Meteorological Society*, **92** (6): 1–23.

Bodner, G., Nakhforoosh, A. and Kaul, H.P. (2015) Management of crop water under drought: a review. *Agronomy for Sustainable Development*, **35**(2):401–442.

Bokal, S., Ania, G., Janusz, K. and Danka, T. (2014) From national to regional plans – the Integrated Drought Management Programme of the Global Water Partnership for Central and Eastern Europe. *Weather and Climate Extremes*, **3**: 37–46.

Bond, R.B., Lake, P.S. and Arthington, A.H (2008) The impacts of drought on freshwater ecosystems: Australian perspectives. *Hydrobiologia*, **600**: 3–16.

Brace, I. (2008) *Questionnaire Design, How to Plan, Structure and Write Survey material for Effective Market Research*. 2nd ed. London: Kogan Page.

Bradford, R.B. (2000) *Drought Events in Europe*. Institute of Hydrology, Wallingford, Oxon, UK.

Brannen, J. (1992) *Combining Qualitative and Quantitative Approaches: An overview*. In Mixing Methods: Qualitative and Quantitative Research, ed. J. Brannen. Avebury, Aldershot, England, pp. 3–37.

Brown, C., Meeks, R., Hunu, K., and Yu, W. (2011) Hydroclimate risk to economic growth in sub-Saharan Africa. *Climatic Change*, **106**: 621–647.

Brusberga, M.D. and Shively, R. (2015) Building drought resilience in agriculture: Partnerships and public outreach. *Weather and Climate Extremes*, **10**: 40–49.

Bryan, E., Deressa, T.T., Gbetibouo, G.A. and Ringler, C. (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environment Science Policy*, **12**: 413–426.

Bryman, A. (2008) *Social Research Methods*. 3rd ed. Oxford: Oxford University Press.

Buchanan-Smith, M. (2000) *Role of Early Warning Systems in Decision Making Processes*. London: Overseas Development Institute, 11pp.

Burke, E.J. and Brown, S.J. (2007) Evaluating uncertainties in the projection of future drought. *Journal of Hydrometeorology*, **9**: 292–299.

Burke, E.J., Brown, S.J. and Christidis, N. (2006) Modelling the recent evolution of global drought and projections for the twenty-first century with the Hadley Centre Climate Model. *Journal of Hydrometeorology*, **7** (5): 1113–1125.

Burke, M., Miguel, E., Satyanath, S., Dykema, J.A. and Lobell, D.B. (2009) Warming increases the risk of civil war in Africa. *Proceedings of the National Academy of Sciences of the United States of America*, **106**: 20670–20674.

Business Review (BR) Romania's Premier Business Magazine (2015) Green saving http://www.business-review.eu/featured/drought-generates-eur-2-bln-in-losses-for-romanian-agriculture-say-local-farmers-85129 (accessed 06/10/2017).

Cammalleri, F. and Vogt, M.J. (2015) On the value of combining different modelled soil moisture products for European drought monitoring. *Journal of Hydrology*, **525**: 547–558.

Carter, T.R., Jones, R.N., Lu, X., Bhadwal, S., Conde, C., Mearns, L.O., O'Neill, B.C., Rounsevell, M.D.A. and Zurek, M.B. (2007) New assessment methods and the characterisation of future conditions. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (Eds.), Climate Change 2007: *Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: University Press, Cambridge, UK, pp. 133–171.

Charlesworth, S.M. (2010) A review of the adaptation and mitigation of global climate change using sustainable drainage in cities. *Journal of Water and Climate Change*, **1**(3): 165–180. DOI: 10.2166/wcc.2010.035.

Christensen, J.H. and Christensen, O.B. (2007) A summary of the prudence Model projections of changes in European climate by the end of this century. *Climate Change*, **81**: 7–30.

Clark, P.U., Alley, R.B. and Pollard, D. (1999) Northern hemisphere ice-sheet influences on global climate change. *Science*, **286**: 1104–1111.

Clemens, M., Jeroen, R., Assela, P., Jaap, E. and Nguyen, H.Q. (2016) Social learning for adaptation to climate change in developing countries: insights from Vietnam. *Journal of Water and Climate Change*, **7**(2): 365–378.

Cohen, L., Manion, L. and Morrison, K. (2007) *Research Methods in Education*. 6th ed. London: Routledge Publications.

Cook, E.R., Seager, R., Cane, M.A. and Stahle, D.W. (2007) North American drought: Reconstructions, causes, and consequences. *Earth-Science Reviews*, **81**(1-2): 93–134.

Cooper, P.J.M., Dimes, J., Rao, K.P.C., Shapiro, B. and Twolmlow, S. (2008) Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Agriculture, Ecosystems and Environmen*t, **126** (1-2): 24–35.

Creswell, J.W. (2003) *Research Design: Qualitative, Quantitative, and Mixed Method Approaches*. Thousand Oaks, Calif., USA: Sage Publications.

Creswell, J.W. (2009) *Research Design; Quantitative, Qualitative and Mixed Methods Approaches*. 3rd ed. London: Sage Publications.

Creswell, J.W. (2014) *Research Design; Quantitative, Qualitative and Mixed Methods Approaches*. 4th ed. London: Sage Publications.

Creswell, J.W. and Clark, V.L.P. (2007) *Designing and Conducting Mixed Methods Research*. California: Sage Publications, Thousand Oaks.

Creswell, J.W., Plano Clark, V.L., Gutmann, M.L. and Hanson, W.E. (2003) *Advanced Mixed Methods Research Designs*. Handbook of mixed methods in social and behavioral research, **209,** 240 pp.

Dabi, D.D. and Anderson, W.P., (1999) Water use for commodity production in Katarko village, northern Nigeria. *Applied Geography*, **19**: 105–122.

Dai, A. (2011) Drought under global warming: a review. *Climate Change*, **2**: 45–65.

Daily Trust (2018). Pastoralist-Farmers Conflicts and the Search for Peaceful Resolution. https://www.dailytrust.com.ng/pastoralist-farmers-conflicts-and-the-search-for-peaceful-resolution.html (accessed 4/5/2018).

Dariush, H., Masoud, Y. and Fereshteh, K. (2010) Coping with drought: the case of poor farmers of south Iran. *Psychology and Developing Societies*, **22**(2): 361–383.

Darkoh, M.B.K. (1998) The nature causes and consequences of desertification in the drylands of Africa. *Land Degradation and Development*, **9**: 1–20.

Davies, E.G.R. and Simonovic, S.P. (2011) Global water resources modelling with an integrated model of the social–economic–environmental system. *Advances in Water Resources*, **34**(6): 684–700.

Davies, S., Buchanan-Smith, M. and Lambert, R. (1991) *Early warning in the Sahel and Horn of Africa*: The state of the art. A review of the literature. Vol **1** of 3, Research Report No. 20. IDS, Brighton, U.K.

Dawoud, M. A. and Abdel Raouf, A. (2002) Groundwater Exploration and Assessment for Rural Communities in Yobe State, North of Nigeria Technical Report, 21p.

De Vaus, D.A. (2007) *Surveys in Social Research.* 5th ed. London: Routledge.

Denscombe, M. (2007) *The Good Research Guide for Small Scale Social Research Projects*. 3rd ed. Glasgow: Bell and Bain Ltd.

Denzin, A.L. and Lincoln, Y.S. (1994) (eds.) *Handbook of Qualitative Research*. Thousand Oaks, California, USA: Sage Publications.

Denzin, N.K. and Lincoln, Y.S. (2005) *The Discipline and Practice of Qualitative Research*. Research Handbook of Qualitative Research, CA: Sage Publications, **2**, 1–28.

Desanker, P.V. and Magadza, C.H.D. (2001) Africa. In: J.J, McCarthy, O.F. Canziani, N.A. Leary, D.J. Doken. and K.S, White (Eds.), Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC Working Group II, Third Assessment Report. Cambridge University Press, *Earth Science Reviews*, **140**: 203–214.

Dile, Y.T. and Srinivasan, R. (2014) Evaluation of CFSR climate data for hydrologic prediction in data-scarce watersheds: an application in the Blue Nile River Basin. *JAWRA Journal of the American Water Resources Association*, **50**(5): 1226-1241.

Drought Network News (DNN) (1998) *Improving Drought Management and Planning through Better Monitoring in Africa*. A Newsletter of the International Drought Information Centre and the National Drought Mitigation Centre. June 1998, **10**, No. 2.

Edossa, C.D., Mukand, S.B. and Asin D.G. (2010) Drought analyses in the Awash River Basin, Ethiopia. *Water Resources Management*, **24**: 1441–1460.

Elijah, E., Ikusemoran, M., Nyanganji, K.J. and Mshelia, H.U. (2017) Detecting and monitoring desertification indicators in Yobe State, Nigeria. *Journal of Environmental issues and Agriculture in Developing Countries*, **9** (1): 22–34.

Eludoyin, A.O. and Eludoyin, O.M. (2017) Drought Mitigation Practices, Ch. 19 in Handbook of Drought and Water Scarcity, Vol. 3: Management of Drought and Water Scarcity, Ed. by Eslamian S. and Eslamian F., Francis and Taylor. Pp 391–403.

Estrela, T., Fidelgo, A. and Pérez, M.A. (2006) *Drought and the European Water Framework Directive. Implications on Spanish river basin districts*. Taylor and Francis, Boca Raton, Florida, pp. 169–191.

Ezeah, C. (2010). Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Abuja, Nigeria. PhD Thesis, University of Wolverhampton.

Ezeah, C. and Roberts, C.L. (2012) Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Nigeria. *Journal of Environmental Management*, **103:** 9–14.

Fafchamps, M., Udry, C. and Czukas, K. (1998) Drought and saving in West Africa: Are livestock a buffer stock? *Journal of Development Economics*, **55**(2): 273–305.

Fan, W. and Yan, Z. (2010) Factors affecting response rates of the web survey: A systematic review. *Computers in Human Behaviour*, **26**(2): 132–139.

Fintell, (2018) How Yobe fights eco challenges as EU, FG end funding of NEAZDP. http://www.myfinancialintelligence.com/content/how-yobe-fights-eco-challenges-eu-fg-end-funding-neazdpn (accessed on 3/5/18).

FME (2012) Federal Ministry of Environment. Great Green Wall for the Sahara and Sahel initiative, National Strategic Action Plan.

Food and Agriculture Organization (FAO) and National Drought Mitigation Centre (NDMC) (2008) *The Near East Drought Planning Manual: Guidelines for Drought Mitigation and Preparedness Planning*. Food and Agriculture Organization of the United Nations (FAO) and National Drought Mitigation Center (NDMC), Rome, Italy.

FAO (2018) Conservation Agriculture in Kenya beating drought and poor harvest. Helping women farmers reach market sustainably. http://www.fao.org/fao-stories/article/en/c/1100298/?utm_content=bufferb2499&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer (accessed 13/05/18).

FAO (2018a) FAO's role in biodiversity. http://www.fao.org/biodiversity/en/?utm_content=buffer5946d&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer (access 22/05/2018).

Federal Government of Nigeria (2005). Committee for the Review of the Implementation of the Convention (CRIC). Combating desertification and mitigating the effects of drought in Nigeria, National Report on the Implementation of the United Nations Convention to Combat Desertification in Countries Experiencing Drought, pp 40.

Federman, D.K., Cortés, F.I.A. and Pérez, M.L. (2014) Constructing a framework for national drought policy: the way forward in Mexico. *Weather and Climate Extremes,* **3**: 90–94.

Fellows, R. and Liu, A. (2008) *Research Methods for Construction*. 3rd ed. Oxford: Blackwell Publishing Ltd.

Feyen, L. and R. Dankers. (2009) Impact of global warming on streamflow drought in Europe. *Journal of Geophysical Resources*, **114**: 17–34.

Fincham, J.E. (2008) Response rates and responsiveness for surveys, standards, and the journal. *American Journal of Pharmaceutical Education*, **72**(2): 43.

Fisher, M. J. and Marshall, A.P. (2009) Understanding descriptive statistics. *Australia Critical Care,* **22** (2): 93–97.

Fleig, A.K., Tallaksen, L.M., Hisdal, H. and Hannah, D.M. (2011) Regional hydrological drought in north-western Europe: linking a new Regional Drought Area Index with weather types. *Hydrological Processes*, **25**(7): 1163–1179.

Freeman, P.K. (2001) Estimating chronic from natural disasters in developing countries. A case study in Honduras. *Annual Bank Conference on Development Economics, Europe: Development Thinking at the Millennium*. Paris, 26–28 June, 10 pp.

Fullen, M.A and Mitchell, D.J. (1994) Desertification and reclamation in North-Central China. *Ambio* (*The Journal of the Royal Swedish Academy of Sciences*), **23**(2): 131–135.

Fussel, H.M. (2009) An updated assessment of the risks from climate change based on research published since the IPCC Fourth Assessment Report. *Climate Change,* **97**: 469–482.

Galaz, V., Moberg, F., Downing, T., Thomalla, F. and Warner, K. (2008) *Ecosystem under Pressure*. Stockholm: Commission on Climate Change and Development.

Garson, G.D. (2016) *Validity and Reliability*. Statistical Publishing Associates. Asheboro North Carolina: Blue Books.

Gautier, D., Denis, D. and Locatelli, B. (2016) Impacts of drought and responses of rural populations in West Africa: a systematic review. *Wiley Interdisciplinary Reviews: Climate Change*, **7**(5): 666–681.

Gbahabo, T.P. (2011) Desertification and rural livelihoods the case study of Gursulu village Yobe State, Nigeria. Faculty of Humanities, University of the Witwatersrand, Johanesburg.

Ghai, D. (1992) The social dynamics of environmental changes in Africa, Whydah Africa Academic Science. *Newsletter*, **21**a, 1-8.

Global Weather Data for SWAT (GWDS) 2018 Available online: http://globalweather.tamu.edu (accessed on 24 July 2018).

Gomm, R. (2008) *Social Research Methodology: A Critical Introduction*. 2nd ed. Basingstoke: Palgrave Macmillan.

Google image map of Nigeria and Yobe State (2017) www.google.com (accessed 24/10/2017).

Gosling, S.N. (2013) The likelihood and potential impact of future change in the large-scale climate-earth system on ecosystem services. *Environmental Science and Policy*, **27**: 15–31.

Guiquin, J., Fuliang, Y. and Zhao, Y. (2012) An analysis of vulnerability to agricultural drought in China using the expand grey relation analysis method. *Procedia Engineering*, **28**: 670–676.

Habiba, U., Rajib S. and Takeuchi, Y. (2012) Farmer's perception and adaptation practices to cope with drought: Perspectives from north western Bangladesh. *International Journal of Disaster Risk Reduction*, **1**: 72–84.

Haji-Kazemi, S., Bjorn, A. and Han, P.K. (2013) Identification of early warning signs in front-end stage of projects, an aid to effective decision making. *Procedia - Social and Behavioural Sciences*, **74**: 212–222.

Hanson, W.E., Creswell, J.W., Clark, V.L.P., Petska, K.P. and Creswell, J.D. (2005) Mixed methods research designs in counseling psychology. *Journal of Counselling Psychology*, **52** (2): 224–235.

Hellmuth, M.E., Osgood, D.E., Hess, U., Moorhead, A. and Bhojwani, H. (2009) *Climate and Society*. Columbia University, New York: International Research Institute for Climate and Society, IRI.

High-level Meeting on National Drought Policy (HMNDP) (2013) *International Conference Centre (CICG)*, Geneva, 11–15 March 2013.

Hill, H., Hadarits, M., Rieger, R., Strickert, G., Davies, E.G. and Strobbe, K.M. (2014) The Invitational Drought Tournament: What is it and why is it a useful tool for drought preparedness and adaptation?. *Weather and Climate Extremes*, **3**: 107–116.

Hisdal, H., Stahl, K.L. Tallaksen, M. and Demuth, S. (2001) Have droughts in Europe become more severe or frequent? *International Journal of Climatology*, **21**: 317–333.

Holden, S.T. and Shiferaw, B. (2004). Land degradation, drought and food security in a less-favoured area in the Ethiopian highlands: a bio-economic model with market imperfections. *Agricultural Economics*, **30**: 31–49.

Hsiu-Fang, H. and Shannon, S.E. (2005) Three approaches to Qualitative Content Analysis. *Qualitative Health Research*, **15** (9): 1277–1288.

Huberman, A. and Miles, M.B. (1994) *Data Management and Analysis Methods*. N. K, Denzin. and Y.S. Lincoln (Eds.), Handbook of Qualitative Research, CA US: Thousand Oaks Sage Publications, 643 pp.

Huberman, A. and Miles, M.B. (2002) *The Qualitative Researcher's Companion*. International Educational and Professional Inc London: Sage Publications.

Hutchinson, T.M and Moran, J. (2005) The Use of Research Assistants in Law Faculties: Balancing Cost Effectiveness and Reciprocity. In Proceedings Faculty of Law Research Interest Group, 1–17, Brisbane.

Idris, N.M. (2011) The effects of climate change in Nigeria. Permalink https://environmentalsynergy.wordpress.com/2011/04/18/comprehensive-approach-to-drought-and-desertification-in-nigeria/ (accessed 01/05/2018).

Intergovernmental Panel on Climate Change (IPCC). (2014) *Climate Change 2001—Impacts, Adaptation, and Vulnerability*: Summary for Policymakers and Technical Summary of the Working Group II Report. IPCC, Geneva, 89 pp.

Intergovernmental Panel on Climate Change (IPCC). (2007) *Climate Change 2007: The Physical Science Basis*. In: S, Solomon., D. Qin, M. Manning, Z. Chen, M, Marquis, K.B, Averyt., M, Tignor, H.L, Miller. (*Eds*.), Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) (2001*) Climate Change 2001* In: Watson, R.T., the Core Writing Team (Eds.), Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom, and New York, USA.

Inter-Ministerial Committee on Drought Assessment (ICDA) (2010) The impact of drought in North Eastern Nigeria. Unpublished report.

(ITF) International Tree Foundation (2017). The Great Green Wall for the Sahara and the Sahel. http://internationaltreefoundation.org/the-great-green-wall-for-the-sahara-and-the-sahel/ (accessed 08/6/2018).

Jenkins, K.L. (2012) *Modelling the Economic and Social Consequences of Drought under Future Projections of Climate Chang*e. PhD thesis, Cambridge: Cambridge University Press.

Kalutara, P., Zhang, G., Setunge, S. and Wakefield, R. (2018) Prioritising sustainability factors for Australian community buildings' management using Analytical Hierarchy Process (AHP). *International Journal of Strategic Property Management*, **22**(1): 37-50.

Kim, H., Jongyong, P., Jiyoung, Y. and Tae-Woong, K. (2015) Assessment of drought hazard, vulnerability, and risk: A case study for administrative districts in South Korea. *Journal of Hydro-environment Research*, **9**: 28–35.

Kinsey, B. (1998) Coping with drought in Zimbabwe: Survey evidence on responses of rural households to risk. *World Development*, **26**(1): 89–l10.

Klein R.J.T and Tol, R.S.J. (1997) *Adaptation to climate change: options and technologies an overview paper*. United Nations Framework Convention on Climate Change Secretariat. Bonn, Germany.

Koutroulis, A.G., Tsanis, I.K., Daliakopoulos, I.N. and Daniela, J. (2013) Impact of climate change on water resources status: A case study for Crete Island, Greece. *Journal of Hydrology*, **479**: 146–158.

Kraaijvanger, A., Almekinders, C.J.M. and Veldkamp. A. (2016) Identifying crop productivity constraints and opportunities using focus group discussions: A case study with farmers from Tigray. *Wageningen Journal of Life Sciences*, **78**: 139–151.

Kumar, R.H., Venkaiah, K., Arlappa, N., Sharad Kumar, G.N., Brahmam V. and Vijayaraghavan, K. (2005) Diet and nutritional status of the population in the severely drought affected areas of Gujarat. *Journal of Human Ecology*, **18**(4): 319–326.

Kusangaya, S., Michele, L., Warburton, van Garderen, E.A. and Graham P.W.J. (2014) Impacts of climate change on water resources in southern Africa: *A review. Physics and Chemistry of the Earth*, **69**: 47–54.

Lambert, K.S. and Shiati, K. (2002) Irrigation and salinity: a perspective review of the salinity hazards of irrigation development in the arid zone. *Irrigation and Drainage System*, **16**(2):161–174.

Lean, G. (1995) Down to Earth: *A simplified Guide to the Convention to Combat Desertification, Why is it Necessary and What is Important and Different about it*. Geneva: Interim Secretariat for the Convention to Combat Desertification, 32 pp.

Lei, Y., Hailin, Z., Fu, C. and Linbo, Z. (2016) How rural land use management facilitates drought risk adaptation in a changing climate — A case study in arid northern China. *Science of the Total Environment*, **550**: 192–199.

Lindseth, G. (2004) The cities for climate protection campaign and the framing of local climate policy. *Local Environment*, **9**: 325–336.

Little, P.D., Stone, M.P., Mogues, T., Castro, A.P. and Negatu, W. (2006) 'Moving in place': Drought and poverty dynamics in South Wollo, Ethiopia. *The Journal of Development Studies*, **42**(2) 200–225.

Lohmann, S. and Lechtenfeld, T. (2015) The effect of drought on health outcomes and health expenditures in rural Vietnam. *World Development*, **72**: 432–448.

Long, D., Scanlon, B.R., Longuevergne, L., Sun, A.Y., Fernando, D.N. and Save, H. (2013) GRACE satellite monitoring of large depletion in water storage in response to the 2011 drought in Texas. *Geophysical Research Letters*, **40**(13), 3395–3401.

Love, G. (2005) Impacts of climate variability on regional Australia. In: ABARE Outlook Conference Proceedings (National Agricultural and Resources Outlook Conference Proceedings), Climate Session Papers. Canberra: Government Department of Agriculture, Fisheries and Forestry, pp. 10–19.

Lu, H., Yihua, W., Yijun, L. and Yongqiang, L. (2017) Effects of meteorological droughts on agricultural water resources in southern China. *Journal of Hydrology*, **548**: 419–435.

MaCaulay, B.M. (2014). Land degradation in Northern Nigeria: The impacts and implications of human-related and climatic factors. *African Journal of Environmental Science and Technology*, **8**(5):267–273.

Marsh, T., Cole, G. and Wilby, R. (2007) Major droughts in England and Wales, 1800–2006. *Weather*, **62**(4): 87–93.

Mato, Y. (2016) Brief about NorthEast Arid Zone Development Programme (NEADZP). http://yahyadanmato.blogspot.co.uk/2016/04/yahaya-mato-gis-and-web2fordev.html?m=1 (accessed 3/5/18).

Millennium Ecosystem Assessment MEA (2005) *Millennium Ecosystem Assessment. Ecosystems and Human Well-being Synthesis*. Washington DC: Island Press.

Medugu, N.I., Rafee Majid, M. and Choji, I.D. (2008) A comprehensive approach to drought and desertification in Nigeria: A brief evaluation of government policies. *Management of Environmental Quality: An International Journal*, **19**(6): 690–704.

Medugu, N.I. (2009) Nigeria and the advancing desert. Environmental Synergy World Press.com.

Mehmet, S.K. and Hakan, A. (2016) Effects of irrigation water salinity on drainage water salinity, evapotranspiration and other leek (*Allium porrum* L.) plant parameters. *Scientia Horticulturae*, **201**: 211–217.

Ministerio de Medio Ambiente. (2005) Assessment Report of the Preliminary Impacts in Spain due to Climate Change, Madrid.

Mirza, M.M.Q. (2003) Climate change and extreme weather events: can developing countries adapt? *Climate Policy*, **3**: 233–248.

Mishra, A.K. and Singh, V.P. (2010) Drought modelling – A review, *Journal of Hydrology*, 403: 157–175.

Mishra, A.K., Sivakumar, B. and Singh, V. (2015) Drought processes, modelling, and mitigation. *Journal of Hydrology*, **526**: 1–2.

Modu, B., Polovina, N., Lan, Y., Konur, S., Asyhari, A.T. and Peng, Y. (2017) Towards a Predictive Analytics-Based Intelligent Malaria Outbreak Warning System. *Applied Sciences*, **7**(8), p.836.

Monnik, K. (2000) Role of Drought Early Warning Systems in South Africa's Evolving Drought Policy. ARC-Institute for Soil, Climate and Water, Pretoria, South Africa 53–64.

Mortimore, M. (1989) *Adapting to drought farmers, famine and desertification in West Africa*. Department of Geography Bayero University Kano, New York, Cambridge University Press.

Mosley, L.M. (2015) Drought impacts on the water quality of freshwater systems; review and integration. *Earth Science Reviews*, **140**: 203–214.

Msangi, J.P. (2004) Drought hazard and desertification management in the dry lands of southern Africa. *Environmental Monitoring Assessment*, **99**: 75-87.

Muller, C.Y. (2014) Adapting to climate change and addressing drought – learning from the Red Cross Red Crescent experiences in the Horn of Africa. *Weather and Climate Extremes*, **3**: 31–36.

Munn, P. and Drever, E. (1990) *Using Questionnaires in Small-Scale Research: A Teachers' Guide*. Edinburgh: SCRE.

Musa, H.D. and Shaib, B. (2010) Integrated remote sensing approach to desertification monitoring in the crop-rangeland area of Yobe State, Nigeria. *Journal of Sustainable Development in Africa*, **12** (5): 236–250.

Musa, K. (2011) Groundwater occurrence in Damaturu and its environs Yobe state, north eastern Nigeria, MSc thesis, Ahmadu Bello University Zaria, Nigeria.

My interesting facts (2014) http://www.myinterestingfacts.com/drought-facts/ (accessed 06/10/2017).

National Centre for Environmental Information (2013) *National Oceanic and Atmospheric Administration.* USA: https://www.ncei.noaa.gov/ (accessed 22/10/2017).

National Drought and Desertification Policy (2007) Federal Ministry of Environment, Abuja Nigeria 30 pp.

National Drought Mitigation Center (NDMC) (2016) http://drought.unl.edu/Home.aspx (accessed 06/10/2017).

National Drought Mitigation Centre (NDPC) (2000) *Preparing for Drought in the 21st Century*. National Drought Policy Commission. Washington DC: US Department of Agriculture.

National Oceanic and Atmospheric Administration/Climate Prediction Center (2016) http://drought.unl.edu/Home.aspx (accessed 06/10/2017).

Naumann, G., Barbosa, P., Garrote, L., Iglesias, A. and Vogt, J. (2013) Exploring drought vulnerability in Africa: an indicator based analysis to inform early warning systems. *Hydrology Earth System Science*, **10**(10): 12217–12254.

Nguyen, V.V. (2011) *Climate change and agricultural production in Vietnam, In W. Filho* (Ed.), The Economic, Social and Political Elements of Climate Change. Berlin, Springer pp. 227–243.

Nigerian Meteorological Agency, NiMET (2015) Yobe State rainfall data 1990–2015 unpublished.

NPC (2006) National Population Commission Official Result for 2006 House and Population Census Figures, Bureau for National Statistics Abuja, Nigeria. Online: http://population.gov.ng/ (accessed on 06/10/2017).

Nwokocha C.O. (2017) The challenges facing the effective implementation of drought and desertification policy in North-east Geo-political zone of Nigeria. *Arts and Social Sciences Journal*, **8** (4): 289–297.

Nwokocha C.O. (2016) An appraisal of the strategies implored by government to combating drought and desertification in the North-East Political Zone 2004-2014. *Review of Public Administration and Management*, **5** (1): 205–211.

Nyong, A., Adesina, F.A. and Elasha, B.O. (2007) The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and Adaptation Strategies for Global Change*, **12**: 787–797.

Obi, N.I. (2012) Desertification and drought risk vulnerability: potential of desertification and drought risk management in northern Nigeria (A case study of Sokoto, Kano and Kaduna). *Journal of Environmental Management and Safety*, **3**(4): 71–79.

Oguntunde, P.G., Abiodun, B.J. and Lischeid, G. (2011) Rainfall trends in Nigeria, 1901–2000. *Journal of Hydrology*, **411**(3–4): 207–218.

Oladipo, E.O. (1993) A comprehensive approach to drought and desertification in Northern Nigeria. *Natural Hazards*, **8**: 235–261.

Olagunju, T.E. (2015) Drought, desertification and the Nigerian environment: A review. *Journal of Ecology and the Natural Environmental*, **7** (7): 196–209.

Olaniyi O.A., Funmilayo, O.A and Olutimehin, I.O. (2014) Review of climate change and its effect on Nigeria ecosystem. *International Journal of Environment and Pollution Research*, **2**(3): 70–81.

Olesen, J.E. and Bindi, M. (2002) Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy*, **16**: 239–262.

Olmstead, S.M. (2014) Climate change adaptation and water resource management: A review of the literature. *Energy Economics*, **46**: 500–509.

Olsson, L. (1993) On the causes of famine – drought, desertification and market failure in the Sudan. *Ambio*, **22**(6): 395–403.

O'Meagher, B. du Pisani, L.G. and White, D.H. (1998) Evolution of drought policy and related science in Australia and South Africa. *Agricultural Systems*, **57** (3): 231–258.

O'Meagher, B., Stafford-Smith, M. and White, D.H. (2000) *Approaches to integrated drought risk management: Australia's national drought policy*. In: D.A. Wilhite, (Ed.), Drought: A Global Assessment. **2**, London: Routledge, p. 115–128.

Pai, D.S., Latha, S., Pulak, G. and Hatwar, H.R. (2011) District-wide drought climatology of the southwest monsoon season over India based on a Standardized Precipitation Index (SPI). *Natural Hazards*, **59**: 1797–1813.

Palmer, W.C. (1965) Meteorological Drought, US Weather Bureau Research Paper 45, Washington D.C.

Pandey, S., Bhandari, H. and Hardy, B. (2007) *Economic costs of drought and rice farmers' coping mechanisms: a cross-country comparative analysis*. Manila: International Rice Research Institute (IRRI), 203 pp.

Parry, M.I. (2000) Assessment of potential effects and adaptations for climate change in Europe. The Europe ACACIA Project Jackson Environment Institute, University of East Anglia, Norwich, UK.

Patton, M.Q. (1990) *Qualitative Evaluation and Research Methods*. Newbury Park, California: SAGE Publications Inc, 532 pp.

Patton, M. (1992) *Qualitative Methods and Approaches: What are they?* In Kuhuns, S.V. (eds) New Direction for Institutional Research, London.

Perkins, G. (2001) Research and assessment systems for sustainability: Framework for vulnerability, The George Perkins Marsh Institute at Clark University and the Stockholm Environment http://www.Clarku.Edu/department/marsh/proiects/vulnerability (accessed 14/06/2016).

Piedallu, C., Gégout, J.C., Ary B. and Seynave, I. (2011) Mapping soil water holding capacity over large areas to predict potential production of forest stands. *Geoderma*, **160**: 355–366.

Pole, C.J. and Lampard, R. (2002) *Practical Social Investigation: Qualitative and Quantitative Methods in Social Research.* Essex: Pearson Education Limited.

Pravalie, R. (2016) Drylands extent and environmental issues. A global approach. *Earth Science Reviews*, 161: 259-278**.**

Qin, Y., Yang, D., Huimin L., Kai, X. and Xiangyu, X. (2014) Comparative analysis of drought based on precipitation and soil moisture indices in the Haihe Basin of North China during the period of 1960–2010. *Journal of Hydrology*, **9**: 61–74.

Reagan, M.W. (1994) Best Management Practises for Irrigation. Colorado State University.

Read, M., Gregory, M. K. and Phillips, P. S. (2009) An evaluation of four key methods for monitoring household waste prevention campaigns in the UK. *Resources, Conservation and Recycling*, **54**(1): 9–20.

Retsas, A. (2000) Barriers to using research evidence in nursing practice. *Journal of Advanced Nursing*, **31**(3): 599–606.

Reynold, J.F. (2016) Desertification. *Reference Module in Life Sciences*, **12**: 479–494.

Rietz, D.N. and Haynes, R.J. (2003) Effects of irrigation-induced salinity and sodicity on soil microbial activity. *Soil Biology and Biochemistry*, **35**(6): 845–854.

Ross, T. and Lott, N. (2003) A climatology of 1980–2003 extreme weather and climate events. National Climatic Data Center Technical Report No. 2003-01. Asheville, NC: NOAA/NESDIS. National Climatic Data Center.

Rubin, R. and Babbie, E.R. (2009) *Essential Research Methods for Social Work (2nd Edition)*. Brooks-Cole, Belmont, California, 384 pp.

Rusca, M., Heun, J. and Schwartz, K. (2012) Water management simulation games and the construction of knowledge. *Hydrological Earth System Science*, **9**: 3063–3085.

Sahr, R.C. (2005) Inflation conversion factors for dollars 1665 to estimated 2015. Political Science Department, Oregon State University.

Sarr, B. (2012) Present and future climate change in the semi-arid region of West Africa: a crucial input for practical adaptation in agriculture. *Atmospheric Science Letters*, **13**(2): 108-112.

Sandelowski, M. (2000) Focus on research methods combining qualitative and quantitative sampling, data collection, and analysis techniques. *Research in Nursing & Health*, **23**(3): 246-255.

Saunders, M., Lewis, P. and Thornhill, A. (2012) *Research Methods for Business Students* 6th edition, London: Pearson Education Limited.

Savo, V., Lepofsky, D., Benner, J.P., Kohfeld, K.E., Bailey, J. and Lertzman, K. (2016) Observations of climate change among subsistence-oriented communities around the world. *Nature Climate Change* **6**: 462–473.

Schaible, G.D. and Aillery, M.P. (2017) Challenges for US irrigated agriculture in the face of emerging demands and climate change. Competition for Water Resources, Chapter 2: 44–79, USDA, Washington, DC: Economic Research Service.

Schär, C., Vidale, P.L., Luthi, D., Frei, C., Haberli, C., Liniger, M.A. and Appenzeller, C. (2004) The role of increasing temperature variability in European summer heatwaves. *Nature*, **427**: 332–336.

Scheffran, J., Marmer, E. and Sow, P. (2012) Migration as a contribution to resilience and innovation in climate adaptation: social networks and co-development in Northwest Africa. *Applied Geography*, **33**: 119–127.

Segura, C., Jimenez, O., Nieto, F.B., Navarro, E. and Fernandez, O. (2016) Changes in soil organic carbon over 20 years after afforestation in semi-arid SE Spain. *Forest Ecology and Management*, **381**: 268–278.

Sen, A. (1999) *Poverty and Famines: An Essay on Entitlement and Deprivation*. New York: Oxford University Press, 257 pp.

Sheffield, J., Wood, E.F. and Roderick, M.L. (2012) Little change in global drought over the past 60 years. *Nature*, **491**: 435–438.

Shen, C., Wang, W.C., Hao, Z. and Gong, W. (2007) Exceptional drought events over eastern China during the last five centuries. *Climatic Change*, **85**(3–4): 453–471.

Shiferaw, B., Kindie, T., Menale, K., Tsedeke, A., Prasanna, B.M. and Abebe, M. (2014) Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. *Weather and Climate Extremes*, **3**: 67–79.

Shiru, M.S., Shahid, S., Alias, N. and Chung, E.S. (2018) Trend analysis of droughts during crop growing seasons of Nigeria. *Sustainability*, 10 (3), p.871.

Shukla, S., and Wood. A. W. (2008) Use of a standardized runoff index for characterizing hydrologic drought. *Geophysical Research Letters*, **35**(2): 29–34.

Singh, N.P. and Byjesh, C.B.K. (2014) Vulnerability and policy relevance to drought in the semi-arid tropics of Asia – A retrospective analysis. *Weather and Climate Extremes*, **3**: 54–61.

Sivakumar, M.V.K. and Wallace, J.S. (1991*) Soil water balance in the Sudano-Sahel zone: need relevance and objectives workshop*. Wallingford: IAHS Publication, 310 pp.

Smakhtin, V.U. and Hughes, D.A. (2007) Automated estimation and analyses of meteorological drought characteristics from monthly rainfall data. *Environmental Modelling and Software*, **22**: 880–890.

Smit, B. and Pilifosova, O. (2003) *From adaptation to adaptive capacity and vulnerability reduction*. In: J.B. Smith. R.J.T. Klein and S. Huq (eds). Climate Change Adaptive Capacity and Development. London: Imperial College Press, pp. 9–28.

Smit, B., Burton, I., Klein, R.J.T. and Street, R. (1999) The science of adaptation: a framework for assessment. *Mitigation Adaptation Strategies for Global Change*, **4**: 199–213.

Smit, I.B., Klein, R.J. and Wandel, J. (2000) An anatomy of adaptation to climate change and variability. *Climatic Change*, **45**: 223–251.

Smith, D.I. (1993) Drought policy and sustainability: lessons from South Africa. *Search*, **24**: 292–295.

Smith, J.B., Schneider, S.H., Oppenheimer, M., Yohe, G.W., Hare, W., Mastrandrea, M.D., Patwardhan, A., Burton, I., Corfee-Morlot, J., Magadza, C.H. and Füssel, H.M. (2009) Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) "reasons for concern". *Proceedings of the National Academy of Sciences*, **106**(11): 4133–4137.

Smith, S. (2010) How to design a questionnaire. *Practical Tourism Research*, **2**: 61-86.

Solh, M. and Maarten, G. (2014) Drought preparedness and drought mitigation in the developing world's drylands. *Weather and Climate Extremes*, **3**: 62–66.

Solomon, S., Qin, D., Manning, M., Averyt, K. and Marquis, M. (2007) *Climate Change 2007-the Physical Science Basis eds*.: Working Group I Contribution to the Fourth Assessment Report of the IPCC, Vol. 4, Cambridge University Press.

Speranza, C.I., Kiteme, B. and Wiesmann, U. (2008) Droughts and famines: the underlying factors and the causal links among agro-pastoral households in semi-arid Makueni District, Kenya. *Global Environmental Change*, **18**(1): 220–233.

Spinoni, J., Naumann, G., Vogt, J. and Barbosa, P. (2015) European drought climatologies and trends based on a multi-indicator approach. *Global and Planetary Change*, *127*: 50–57.

Stone, D.H., 1993. Design a questionnaire. *Bmj*, **307**(6914): 1264-1266.

Stone, R.C. (2014) Constructing a framework for national drought policy: The way forward – The way Australia developed and implemented the national drought policy. *Weather and Climate Extremes*, **3**: 117–125.

Stott, P.A., Stone, D.A. and Allen, M.R. (2004) Human contribution to the European heatwave of 2003. *Nature*, **432**: 610–613.

Straub, D.W. (1989) Validating instruments in MIS research, *MIS Quarterly*, **2**(13): 147–169.

Straub, D., Boudreau, M.C. and Gefen, D. (2004) Validation guidelines for IS positivist Research. *Communications of the Association for Information Systems*, **13** (14): 380–427.

Tannehill, I.R. (1947). Drought: Its causes and effects. *Soil Science*, **64**(1): 83.

Terhile, A. (2017) Desert encroachment and security challenges in North East Nigeria. Department of Political Science, University of Calabar, Nigeria.

Thomas, A.C., Reager, J.T., Famiglietti, J.S. and Rodell, M. (2014) A GRACE-based water storage deficit approach for hydrological drought characterization. *Geophysical Research Letters*, **41**(5): 1537–1545.

Thomson, A., Jenden, P. and Clay. E. (1998) *Information, risk and disaster preparedness: Responses to the 1997 El-Nino event*. Research Report. London: DFID ESCOR No. AG1215.

Tideman, E. and Khatana, V. (2004) *Drought coping strategies in semi-arid India, Indo-German Bilateral Projects*. Watershed Management German Technical Cooperation.

Tobih. F.O., Okonmah, L.U. and Omoloye, A.A. (2011) Assessment of yield potentials and damage of yams in uncontrolled upland yam monocrop system with varying planting dates in Oshimili area of Delta State, Nigeria. *International Journal of Agricultural Science*, **1** (3): 811–871.

Trambauer, P., Maskey, S., Winsemius, H., Werner, M. and Uhlenbrook, S. (2013) A review of continental scale hydrological models and their suitability for drought forecasting in (sub-Saharan) Africa. *Physics and Chemistry of the Earth*, **66**: 16–26.

Tsanis, I.K., Koutroulis, A.G., Daliakopoulos, I.N. and Jacob, D. (2011) Severe climate induced water shortage and extremes in Crete. *Climate Change*, **106**(4): 667–677.

Udmale, P., YutakaI, C., Sujata, M., Hiroshi, I. and Kiem, A.S. (2014) Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction*, **10**: 250–269.

United Nations (2008) Trends in Sustainable Development. *Agriculture, Rural Development, Land, Desertification and Drought.* United Nations. New York: Department of Economic and Social Affairs.

UN/ISDR (United Nations International Strategy for Disaster Reduction). (2004) *Living with Risk*. A Global Review of Disaster Reduction Initiatives, United Nations, Geneva.

UN/ISDR. (2011) Global Assessment Report on Disaster Risk Reduction: Revealing Risk.

United Nations Environment Programme (UNEP): (1992) *UN Feature Desertification, The Problem that Won't Go*. Nairobi: UNEP.

Union of Concerned Scientists (2012) *Extreme Weather and Climate Change* http://www.ucsusa.org/global_warming/science_and_impacts/impacts/extreme-weather-climate-change.html#.Vc4Kyvm-18F (accessed 06/10/2017).

UNISDR. 2009. *Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action*, United Nations Secretariat of the International Strategy for Disaster Reduction, Geneva, Switzerland, 213 pp.

UNISDR (United Nations International Strategy for Disaster Reduction) (2011) *Global Assessment Report on Disaster Risk Reduction 2011*. Geneva: United Nations International Strategy for Disaster Reduction Secretariat.

United Nations Environment Programme (UNEP). (2006) Geo Year Book 2006: An Overview of Our Changing Environment, Nairobi.

United Nations Humanitarian Aid and Relief (2012) Stories and updates from world concern. United Nations Publication, Redefining Development, UK.

Van Loon, A.F. and Laaha, G. (2014) Hydrological drought severity explained by climate and catchment characteristics. *Journal of Hydrology*, **19**: 1–12.

Vicente-Serrano, S.M., Beguería, S., Gimeno, L., Eklundh, L., Giuliani, G., Weston, D., El Kenawy, A., López-Moreno, J.I., Nieto, R., Ayenew, T. and Konte, D. (2012) Challenges for drought mitigation in Africa: The potential use of geospatial data and drought information systems. *Applied Geography*, **34**, pp.471-486.

Von Uexkull, N. (2014) Sustained drought, vulnerability and civil conflict in Sub-Saharan Africa. *Political Geography*, **43**: 16-26.

Walker, C.M. (1997) Comparative features of hepatitis C virus infection in humans and chimpanzees. *Springer Seminars in Immunopathology*, **19**(1): 85–98.

Wanders, N. and Van Lanen, H.A.J. (2013) Future hydrological drought across climate regions around the world modelled with a synthetic hydrological modelling approach

forced by three general circulation models. *Natural Hazards Earth System Science*, **1**: 7701–7738.

Wanders, N. and Wada, Y. (2014) Human and climate impacts on the 21st century hydrological drought. *Journal of Hydrology*, **10**: 47–60.

Wang, A., Lettenmaier, D.P. and Sheffield, J. (2011) Soil moisture drought in China, 1950–2006. *Journal of Climate*, **24** (13): 3257–3271.

West, C.T., Roncoli, C. and Ouattara, F. (2008). Local perceptions and regional climate trends on the Central Plateau of Burkina Faso. *Land Degradation & Development*, **19**(3): 289–304.

Wheaton, E., Kulshreshtha, S., Wittrock, V. and Koshida, G. (2008) Dry times: hard lessons from the Canadian drought of 2001 and 2002. *Canadian Association of Geographers*, **52**(2): 241–262.

White, D.H., Botterill, L.C. and O'Meagher, B. (2005) *At the intersection of science and politics: defining exceptional drought*. In: L.C. Botterill, and D.A. Wilhite, (Eds), From Disaster Response to Risk Management Australia's National Drought Policy. Springer, Dordrecht The Netherlands, pp. 99–11.

Wilhite, D.A. and Buchanan-Smith, M., 2005. Drought as hazard: understanding the natural and social context. *Drought and Water Crises: Science, Technology, and Management Issues*, pp.3–29.

Wilhite, D.A. (1996) A methodology for drought preparedness. *Natural Hazards*, **13**: 229–252.

Wilhite, D.A. (2002) Combating drought through preparedness. *Natural Resources Forum*, **26**: 275–285.

Wilhite, D.A. (2005) *Drought and Water Crises Science, Technology, and Management Issues*. Taylor and Francis, Boca Raton, Florida: CRC Press.

Wilhite, D.A. (2016) *Drought Management Policies*. Oxford: Elsevier.

Wilhite, D.A. and Pulwarty, R.S. (2005) *Drought and water crises: lessons learned and the road ahead*. In: Botterill, L.C. and Wilhite, D.A. (Eds.), Drought and Water Crises: Science, Technology, and Management Issues. CRC Press, Boca Raton, FL, p. 389–398.

Wilhite, D.A. and Svoboda, M.D. (2000) *Drought early warning systems in the context of drought preparedness and mitigation* In: Proceedings of an Expert Group Meeting on Early Warning Systems, September 5–7, 2000, Lisbon, Portugal.

Wilhite, D.A., Hayes, M., Knutson, C. and Smith, K.H. (2000) Planning for drought: Moving from crisis to risk management. *Journal of the American Water Resources Association*, **36** (4).

Wilhite, D.A., Hayes, M.J. and Knutson, C.L. (2005) *Drought preparedness planning: Building institutional capacity* (Chapter 5), pp. 93–136. In: Drought and Water Crises: Science, Technology, and Management Issues, L.C. Botterill and D.A. Wilhite, Eds. CRC Press, Boca Raton, Florida:.

Wilhite, D.A., Svoboda, M.D. and Hayes, M.J. (2007) Understanding the complex impacts of drought: a key to enhancing drought mitigation and preparedness. *Water Resources Management*, **21**(5): 763–774.

Witt, A., Fürst, C., Frank, S., Koschke, L. and Makeschin, F. (2013) Regionalisation of climate change sensitive forest development types for potential afforestation areas. *Journal of Environmental Management*, **127**: 48-55.

Wood, A., Stedman, E.P. and Msangi, J. (2000) *The Root Causes of Biodiversity Loss, Macroeconomics for Sustainable Development*. WWF International, Earthscan, London, 399 pp.

World Bank. (2012) Vietnam Development Report. Washington, DC.

World Food Programme (WFP) (2018). How Farmers in Kenya Are Beating the Effects of drought. http://www.wfp.org/stories/farmers-kenya%E2%80%99s-semi-arid-lands-beating-effects-drought (accessed 5/5/2018).

Wossen, T., Abdoulaye, T., Arega, A., Shifarew, F., Menkir, A. and Manyong, V. (2017) Measuring the impacts of adaptation strategies to drought stress: the case of drought tolerant maize varieties. *Journal of Environmental Management*, **203**(1): 106–113.

Yaduvanshi, A., Prashant K.S and Pandey, A.C. (2015) Integrating TRMM and MODIS satellite with socio-economic vulnerability for monitoring drought risk over a tropical region of India. *Physics and Chemistry of the Earth*, **6**: 8–22.

Yin, R. (1994) *Case Study Research: Design and Methods*, 2th edition. Sage, Beverly Hills.

Yin, R.K. (2003) *Case Study Research: Design and Methods*, 3rd Edn., Sage Publications, California.

Yobe State Government of Nigeria (2010) *Position on the Proposed Construction of the Kafin Zaki Dam*. Unpublished Report.

Zarafshani, K., Lida, S., Hossein, A., Gholamhossein, H., Philippe, D.M. and Frank, W. (2012) Drought vulnerability assessment: The case of wheat farmers in Western Iran. *Global and Planetary Change*, **99**: 122–130.

Zhou, H., Zhang,W., Sun, Y. and Yuan, Y. (2014) Policy options to support climate-induced migration: insights from disaster relief in China. *Mitigation and Adaptation Strategies for Global Change*, **19**: 375–389.

Zimmerman, F.J. and Carter, M.R. (2003) Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints. *Journal of Development Economics*, **71**: 233–260.

Zou, P.X., Sunindijo, R.Y. and Dainty, A.R. (2014) A mixed methods research design for bridging the gap between research and practice in construction safety. *Safety science*, **70**: 316–326.

APPENDICES

Appendix (A) Ethics form approval

Ethics form approval

Dear Abdullahi Hassan Gana

Please take this email as official confirmation that your ethics form has been approved on 11/01/2016.

Approved form attached.

Kind regards,
Pierre – Lloyd Parson
Research Administrator
Faculty of Science & Engineering (MI310)
University of Wolverhampton, City Campus (Wulfruna), Wulfruna Street, Wolverhampton, WV1 1LY
Tel: (UK) 01902 518530

Appendix (B) Questionnaire

This questionnaire is to be administered to farmers in Yobe State, Nigeria.

GENERAL INSTRUCTIONS

Please, answer all the questions to the best of your knowledge and experience on drought. All the questions are asked on drought but in different sections, each section has different aspects to it. The questions should be answered by either ticking or circling the option you feel answers the question. Some questions have rating options 1-5, where 5 is highest, tick the best suitable answer you think is right.

Section A General Information

This section is to acquire information on the respondent

1. Specify your gender

(a) Male (b) Female

2. Are you employed?

Yes ☐ No ☐

3. Are you a full-time farmer?

Yes	No	Part-time farmer

4. Which type of farming do you do?

(a) Irrigated farming (b) Rain-fed farming (c) Livestock (d) Mixed-farming

Section B Drought Details

This section is to gather information on how drought affects the respondent

5. How well do you know drought? Rate

1	**2**	**3**	**4**	**5**
Not very well	Moderate	High	Very well	Extremely

6. Are you or have you ever been a drought victim?

Yes No

7. Do you know someone affected by drought?

Yes No if yes tick amongst the options the number of people you know

(a) 1-5 (b) 6-10 (c) 10-15 (d) 16-20 (E) 20 and above

8. Rate how drought affects your harvest

1	**2**	**3**	**4**	**5**
Little	Moderate	Neutral	High	Severe

9. Rate how drought affects your social activity

1	**2**	**3**	**4**	**5**
Little	Moderate	Neutral	High	Severe

10. Does drought affect your income?

1	**2**	**3**	**4**	**5**
Little	Moderate	Neutral	High	Severe

11. In the past 10 years how many drought events have you faced?

(a) 0-2 (b) 3-5 (c) 6-9 (d) 10 and above

12. What percent of your harvest have you lost to drought events in the last 10 years?

(a) 10-20% (b) 30-40% (c) 50-60% (d) 70-80% (e) 90-100%

13. What in your opinion causes drought?

(a) Changes in weather and climate (b) Act of God (c) none (d) other specify

14. What else do you think drought affects, apart from you livestock and harvest? State

15. Rate how drought affects your livestock?

1	**2**	**3**	**4**	**5**
Little	Moderate	Neutral	Very Strongly	Extremely

16. If drought persists, what happens to your livestock?

17. If you have livestock, how many died due to drought over the period it lasted?

(a) 0-5 (b) 6-10 (c) 11-15 (d) 16-20 (e) 20 and above

18. Rate how drought can cause conflict in communities

1	**2**	**3**	**4**	**5**
Little	Moderate	Neutral	High	Very much

Section C Drought Coping Strategy and Environmental Damage

This section on Drought Coping and how it affects the environment

19. When do you store excess harvest due to drought uncertainty?

1	**2**	**3**	**4**	**5**
I do not store	When drought is frequent	Never	Always store	Never stored

20. Which of the following drought coping strategies do you use? Tick one

(a) Reduce area of harvest (b) sell stored stock (c) sale livestock (d) Migration (e) I do not harvest

21. Do you think livestock sales compensate for drought loss? Rate

1	2	3	4	5
Strongly disagree	Disagree	Do not know	Agree	Strongly agree

22. Which of the following drought coping strategies do you do if drought persists and you are out of stock?

1	2	3	4
Over-harvest your farming	Hunt wild animals	Cut down trees	Resort to fishing

23. In the availability of sufficient water supplies, do you think irrigation is an alternative during drought?

(a) It is an alternative during drought **(b)** It is always an alternative **(c)** in rare cases **(d)** not an alternative

24. State what you would do if out of livestock and have no alternative source of income? Comment

25. Do you think drought increases your probability of depending on the immediate environment?

(a) Yes ☐ (b) No ☐ if yes, what exactly?

26. Choose from 1-5 on how poverty contributes to environmental destruction

1	**2**	**3**	**4**	**5**
Little	Moderate	Neutral	Severe	Very severe

27. Do you think drought causes desertification?

(a) Yes ☐ (b) No ☐

28. Please rate how you think drought has increased desertification over the years?

1	**2**	**3**	**4**
Seriously increased	It has increased	Not increased	I have not noticed

Section D Drought Mitigation or Solution

This section is how to mitigate the effects of drought in the region by understanding the views of the victims

29. Do you think improved social welfare and infrastructure will reduce drought effects?

1	**2**	**3**	**4**	**5**
Strongly disagree	Disagree	No idea	Agree	Strongly agree

30. Do you think government's intervention, such as relief during drought, will reduce drought effects?

1	**2**	**3**	**4**	**5**
Strongly disagree	Disagree	No idea	Agree	Strongly agree

31. Have you had any relief or assistance from any organisation either governmental or non-governmental before?

1	**2**	**3**	**4**
Never had relief	No relief	Previously had relief	There is always relief

32. Do think loans from governments or private sector will assist in reducing drought effects?

1	**2**	**3**	**4**	**5**
Strongly disagree	Disagree	No idea	Agree	Strongly agree

33. What do you think people should do on their own to reduce the effects of drought without any intervention? Comment

Appendix (C) Invitation to participate in questionnaire survey

UNIVERSITY OF WOLVERHAMPTON
KNOWLEDGE ▪ INNOVATION ▪ ENTERPRISE

INVITATION TO PARTICIPATE IN QUESTIONNAIRE SURVEY

Dear Sir,

I am a Ph.D research student at the University of Wolverhampton undertaking a research project entitled: "Socio-economic effects of drought in Yobe State, Nigeria". The doctoral research is partially sponsored by Yobe State Government and Yobe State University. As part of this work, therefore, I would like to invite you to kindly participate in answering a questionnaire survey, and the research aims *to develop a framework for the amelioration of drought in Yobe State as a planning and management tool for the State Government*.

The purpose of this survey is to investigate and obtain data on the socio-economic effects of drought in Yobe State. A copy of the survey questions is attached. It is estimated that about 25 minutes of your time will be required to answer the questions. Data obtained from the survey will be treated with strict confidence and used for academic purposes only. No records will bear your identity. The survey will be conducted from the last week of November 2015 to the last week of January 2016. The questionnaire comprises of three sections. These are: Section A General Information, Section B Drought details and Section C Drought Coping Strategy and Environmental Damage. All necessary details and instructions on how to answer the questionnaire are included.

If you have any questions or queries, please do not hesitate to contact me. Thank you very much in advance for your time and valuable assistance in this research.

Yours sincerely,

Abdullahi Hassan Gana

Doctoral Research Student

Faculty of Science and Engineering

University of Wolverhampton

Wulfruna Street

WV1 1LY

Mob: +2348033194624 & +447917912949

Email: A.hassangana@wlv.ac.uk & Hassangana09@gmail.com

Appendix (D) Focus Group Discussions Questions

FOCUS GROUP DISCUSSION

These are questions designed for Focus Group Discussion participants in Yobe State on the impacts of drought and possible mitigation measures. The questions are split into three categories in order to obtain information on drought problems. The categories include experts, farmers, residents, policy-makers and decision-makers.

Questions for farmers

- Apart from the mentioned statistics of drought impacts in the State, what other detail or aspect do you think should be brought to light?
- Describe the rainfall pattern in your area(s)?
- What measures do take during drought as community social responsibility to help mitigate its impacts amongst affected people?
- In your opinion(s) what would you suggest you think will help mitigate the impacts of drought?

Questions for experts

- What are the most effective measures would you recommend to assist in mitigating the impacts of drought in the State?
- If the impacts of drought continue at a consistent pace, as now, how do you see the future of the environment in the State?
- How do you think proper drought mitigation would help improve environmental quality?

Questions for policy-makers

- What in your opinion(s) do you think causes lack of support to the people?
- What challenges do you think will affect the process of developing a drought policy to curtail the issue of drought in the State?
- Do you think developing and implementing drought policy in the State will assist the mitigation of impacts of drought in the State?

Questions for decision-makers

- Do you think as part of mitigation measures, implementing drought policy would reduce the impacts of drought?
- What other factors do you think will affect the implementation of drought policy in the State?
- Apart from drought policy, what other measures do you think can be taken in order to mitigate the impacts of drought?

Appendix (E) Invitation to participate in focus group discussion

UNIVERSITY OF WOLVERHAMPTON
KNOWLEDGE ▪ INNOVATION ▪ ENTERPRISE

INVITATION TO PARTICIPATE IN FOCUS GROUP DISCUSSION

Dear Sir,

I am a Ph.D research student at the University of Wolverhampton undertaking a research project entitled: "**Socio-economic effects of drought in Yobe State, Nigeria**". The doctoral research is partially sponsored by Yobe State Government and Yobe State University. As part of this work, therefore, I would like to invite you to kindly participate in a Focus Group Discussion. The research aims *to develop a framework for the amelioration of drought in Yobe State as a planning and management tool for the State Government*.

The purpose of this discussion is to investigate and obtain data on the socio-economic effects of drought and possible mitigation measures that are suitable for the State. This is to help find solutions to the devastating drought issues in the State. According to the analysis of the first data there is strong evidence of severe drought impact. It is estimated that about 1hr of your time will be required to participate in the discussion. The session will be recorded (voice and video) to give the researcher enough detail for transcription and analysis. The discussion will comprise different groups, including farmers, residents, experts, policy-makers and decision-makers. This is to help gather opinions of the different participants and their perspectives on the subject matter. Data obtained from the survey will be treated in strict confidence and used for academic purposes only. After the research work all the records will be destroyed.

If you have any questions or queries, please do not hesitate to contact me. Thank you very much in advance for your time and valuable assistance in this research.

Yours sincerely,

Abdullahi Hassan Gana
Doctoral Research Student
Faculty of Science and Engineering
University of Wolverhampton
Wulfruna Street
WV1 1LY
Mob: +2348033194624 & +447442332019
Email: A.hassangana@wlv.ac.uk & Hassangana09@gmail.com

Appendix (F) Framework evaluation questions

These are series of question that would be used to evaluate drought mitigation and management framework for stakeholders.

Farmers' questions

- Would all the measures proposed in the sector Frameworks address the effects of drought and how?
- Would you be able to re-introduce the traditional measures (*kaifu* and *miski*) in communities?
- What do you think will affect establishing a community drought mitigation platform?

Officials Ministry of Environment (MoE) Questions

- Would all the measures proposed in the sector Frameworks address the effects of drought?
- Do you think giving responsibility to victims or farmers will help you reduce drought shock?
- How do you think farmers' responsibility would help drought mitigation and management?
- What are the possible barriers that would affect the implementation of the Drought Mitigation and Management Framework?
- Do you think all the Frameworks are applicable and workable (practical)?
- Do you find the Framework relevant to address the situation in Yobe State?
- How clear is the Framework?
- What other suggestions would you give to improve framework implementation and workability?

Appendix (G) Invitation to participate in framework validation

UNIVERSITY OF WOLVERHAMPTON
KNOWLEDGE ▪ INNOVATION ▪ ENTERPRISE

INVITATION TO PARTICIPATE IN FRAMEWORK VALIDATION

Dear Sir/Madam,

I am a PhD research student at the University of Wolverhampton undertaking a research entitled: "**Socio-economic effects of drought in Yobe State, Nigeria**". The doctoral research is partially sponsored by Yobe State Government and Yobe State University. As part of this work, therefore, I would like to invite you to kindly participate in a framework evaluation. The research aims *to develop a framework for the amelioration of drought in Yobe State as a planning and management tool for the State Government*. The purpose of this discussion is to investigate and obtain data on the socio-economic effects of drought and possible mitigation measures that are suitable for the State. This is to help find solutions to the devastating drought issues in the State. According to the analysis of the initial data there is strong evidence of severe drought impacts. It is estimated that about 1hr of your time will be required to participate in the discussion. The session will be recorded (voice and video) to give the researcher enough detail for transcription and analysis. A Research Assistant will to help record the interview sessions. The researcher will also ring you for further information after the session. This is to help gather opinions of the different participants and their perspectives on the subject matter. Data obtained from the session will be treated with strict confidence and used for academic purposes only. After the research work, all records will be destroyed. If you have any questions or queries, please do not hesitate to contact me.

Thank you very much in advance for your time and valuable assistance in this research.

Yours faithfully,

Abdullahi Hassan Gana
Doctoral Research Student
Faculty of Science and Engineering
University of Wolverhampton
Wulfruna Street
WV1 1LY
Mob: +2348033194624 & +447442332019
Email: A.hassangana@wlv.ac.uk & Hassangana09@gmail.com

Appendix (H) Publications and presentations

Publication

Abdullahi, H.G., Fullen, M.A. and Oloke, D. (2016). Socio-economic effects of drought in the semi-arid Sahel: a review. *International Journal of Advances in Science Engineering and Technology*, 1: 95-99. DOI (IJASEAT-IRAJ-DOI-3925).

Publications under review

Title: Problems of drought and its management in Yobe State, Nigeria.

Journal: Weather and Climate Extremes.

Title: Effects of drought in Yobe State, Nigeria

Journal: Earth Science Reviews

Seminars

'Built Environment and Engineering Research Seminars' (BEERS) Series on 18/05/2016. Title: Socio-economic effects of drought in Yobe State, Nigeria review.

'Built Environment and Engineering Research Seminars' (BEERS) Series on 17/05/2017. Title: Socio-economic effects of drought in Yobe State, Nigeria: empirical analysis and proposed framework.

Conference

International conference on 'Environment and Natural Resources' held on 13 November, 2015 in Dubai. Paper entitled 'Socio-economic effects of drought in the semi-arid Sahel: a review'.